Draft Final 2005 Five-Year Review Report
for
Rocky Mountain Arsenal
Commerce City
Adams County, Colorado

Review Period: April 1, 2000 – March 31, 2005

April 2007

PREPARED BY:

Department of the Army
Rocky Mountain Arsenal
Commerce City, Colorado

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ACRONYMS

µg/l	Micrograms per liter
mg/l	Milligrams per liter
ACM	Asbestos-Containing Material
ARAR	Applicable or Relevant and Appropriate Requirement
BANCS	Basin A Neck Containment System
BAS	Biological Advisory Subcommittee
CAMU	Corrective Action Management Unit
CBSG	Colorado Basic Standard for Groundwater
CBSMSW	Colorado Basic Standards and Methodologies for Surface Water
CCR	Construction Completion Report
CCD	CERCLA Compliance Document
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CFS	Confined Flow System
COC	Contaminant of Concern
CQA	Construction Quality Assurance
CQC	Construction Quality Control
CRL	Certified Reporting Limit
CSRG	Containment System Remediation Goal
CSV	Contingent Soil Volume
cy	cubic yard
DAAMS	Depot Area Air Monitoring System
DBCP	1-2,-dibromo-3-chloropropane
DCN	Design Change Notice
DIMP	Diisopropylmethylphosphonate
ELF	Enhanced Hazardous Waste Landfill
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Difference(s)
ESL	Existing (Sanitary) Landfill
FFA	Federal Facility Agreement
ft.	Foot/Feet
FY	fiscal year
FYR	Five-Year Review
FYRR	Five-Year Review Report
GB	Sarin Chemical Agent
gpm	gallons per minute
HHE	Human Health Exceedance
HQ	Hazard Quotient
HWL	Hazardous Waste Landfill
ICS	Irondale Containment System
IRA	Interim Response Action
LNAPL	Light Non-aqueous Phase Liquid
LTMP	Long-Term Groundwater Monitoring Plan
LWTU	Landfill Wastewater Treatment Unit

MEC	Munitions and Explosives of Concern
MRL	Method Reporting Limit
NBCS	North Boundary Containment System
NDMA	n- nitrosodimethylamine
NPL	National Priorities List
NODp	Notice of Partial Deletion
NOIDp	Notice of Intent for Partial Deletion
NPS	Northern Pathway System
NWBCS	Northwest Boundary Containment System
O&M	Operation and Maintenance
OAR	Operational Assessment Report
OCP	Organochlorine pesticide
OGITS	Off-Post Groundwater Intercept and Treatment System
OU	Operable Unit
P1	Priority 1
P2	Priority 2
PCB	Polychlorinated biphenyl
PM-10	Particulate Matter less than 10 Micrometers in Diameter
PMC	Program Management Contractor
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RCWM	Recovered Chemical Warfare Materiel
RDIS	Remediation Design and Implementation Schedule
RER	Residual Ecological Risk
RI	Remedial Investigation
RMA	Rocky Mountain Arsenal
ROD	Record of Decision
RS/S	Off-Post Remediation Scope and Schedule
RVO	Remediation Venture Office
RWMP	Remediation Waste Management Plan
SEO	State Engineer's Office
SWAQMP	Site-Wide Air Quality Monitoring Program Plan
TBC	To-Be-Considered Criteria
TCHD	Tri-County Health Department
TCLP	Toxicity Characteristic Leaching Procedure
TRER	Terrestrial Residual Ecological Risk
TSCA	Toxic Substances Control Act
UFS	Unconfined Flow System
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WWTU	Wastewater Treatment Unit

Executive Summary

Background

The Army established Rocky Mountain Arsenal (RMA) in 1942 to produce chemical warfare agents and incendiary munitions used in World War II. Following the war and through the early 1980s, the Army continued to use these facilities. Beginning in 1946, some RMA facilities were leased to private companies to manufacture industrial and agricultural chemicals. Shell Oil Corporation (Shell), the principal lessee, manufactured primarily pesticides at RMA from 1952 to 1982. Common industrial and waste disposal practices during those years resulted in significant levels of contamination. Approximately 70 chemicals were the focus of the Remedial Investigation (RI) for the On-Post Operable Unit (OU) (Ebasco 1989a, 1992). Of these, the principal contaminants are organochlorine pesticides (OCPs), heavy metals, agent-degradation products and manufacturing by-products, and chlorinated and aromatic solvents.

The RI and subsequent investigations have identified chemicals at more than 180 sites contaminating soil, ditches, stream and lakebed sediments, sewers, groundwater, surface water, biota, and structures. Unexploded ordnance (UXO) has been identified at several locations on-site. Contaminated areas identified in the RI included approximately 3,000 acres of soil, 15 groundwater plumes, and 798 structures. Sites that posed potential immediate risks to human health and the environment were addressed through Interim Response Actions (IRAs), which were followed by the actions required by the On-Post Record of Decision (ROD) (FWENC 1996a).

Groundwater contamination migrated off-post prior to the implementation of groundwater pump and treat systems, resulting in the need for the Off-Post OU, which addresses groundwater contamination north and northwest of RMA. The risk assessment performed for the Off-Post OU indicated that only human exposure via contaminated groundwater needed to be addressed. As a result an Off-Post ROD was prepared and approved on December 19, 1995 (HLA 1995).

Current and future land use for the On-Post OU has been restricted based on the fact that the area is ecologically unique and based on the land use restrictions established by the Federal Facility Agreement (FFA) (EPA 1989) and the On-Post ROD. Surrounded by development, the On-Post OU provides a refuge for an abundant diversity of flora and fauna. For this reason the site was designated as a future National Wildlife Refuge in the Rocky Mountain Arsenal National Wildlife Refuge Act (Refuge Act) of 1992 (PL 102-402 1992).

As components of the remedy are completed, jurisdiction will be administratively transferred to the U.S. Fish and Wildlife Service (USFWS) or other parties purchasing the land, except for the property and facilities continuing to be used for response actions. In addition, the portions of the On-Post OU transferred to other parties will be subject to restrictions prohibiting residential or industrial use, use of groundwater on the site as a source of potable water, hunting and fishing for consumptive use, and agricultural use. Current and future land use of the Off-Post OU has not been restricted, though groundwater use has been restricted through a series of institutional controls identified in the Off-Post ROD.

As of the publication of the 2005 Five-Year Review Report (FYRR), nearly eighty percent of the RMA has been deleted from the National Priorities List (NPL) and more than twelve thousand acres have been transferred to the USFWS, with official establishment of the Rocky Mountain Arsenal National Wildlife Refuge occurring on April 21, 2004.

Protectiveness Statements

The protection of human health and the environment of the remedial actions at both the On-Post and Off-Post OUs are discussed below. All controls are in place to adequately minimize risks. Because the remedial actions at both the On-Post and Off-Post OUs are expected to be protective of human health and the environment upon completion, the remedy for the entire site is expected to be protective of both human health and the environment.

On-Post Operable Unit

The Army has concluded that the remedy at the On-Post OU is expected to be protective upon completion or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

All immediate threats have been adequately addressed in the form of IRAs, and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the On-Post ROD, as appropriate. The Hazardous Waste Landfill (HWL) and Enhanced Hazardous Waste Landfill (ELF), which are central to the effective implementation of the remedy, have been expeditiously constructed and are operational. All other implementation projects are on schedule and in compliance with all elements of the On-Post ROD. Air, water, and biota (wildlife) monitoring programs are comprehensive in their design and effective in their implementation. Contaminant migration is being adequately controlled. Risks to human health and the environment are also being controlled by completion of remedial actions, by a comprehensive worker protection and access control program, by institutional controls and by past implementation of IRAs.

Off-Post Operable Unit

The Army has concluded that the remedy at the Off-Post OU is expected to be protective upon completion or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

All immediate threats have been adequately addressed in the form of IRAs and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the Off-Post ROD, as appropriate. Administrative controls to protect the public have been effective in their implementation. Groundwater contamination is being treated to ROD remediation goals at both the RMA boundary and the Off-Post Groundwater Intercept and Treatment System (OGITS).

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Rocky Mountain Arsenal		
EPA ID: CO5210020769		
Region: VIII	**State:** CO	**City/County:** Commerce City/Adams County
SITE STATUS		
NPL Status: ☒ **Final** ☐ **Deleted** ☒ **Other (specify)** Some RMA land deleted from NPL		
Remediation Status: ☒ **Under Construction** ☒ **Operating** ☒**Complete**		
Multiple OUs? ☒ **Yes** ☐ **No**	**Construction Completion Date:** September 30, 2011	
Has site been put into reuse? ☐**Yes** ☒**No** (Re-use planned on approximately 13,000 acres of land "deleted" from the NPL)		
REVIEW STATUS		
Reviewing Agency: ☐**EPA** ☐**State** ☐**Tribe** ☒**Other Federal Agency:** Army		
Author Name: Bruce Huenefeld		
Author Title: RMA Committee Chairman	**Author Affiliation:** Army	
Review Period: April 1, 2000 – March 31, 2005		
Date(s) of Site Inspection: April 18 , 2005 – June 30, 2005		
Type of review: ☒**Statutory** ☐**Policy (Post-SARA)**		
Review Number: ☐**First** ☒**Second** ☐**Third** ☐**Other (specify)**____________		
Triggering Action: ☐**Actual RA Onsite Construction at OU** ☐**Actual RA Start at OU** ☐**Construction Completion** ☐**Previous Five-Year Review Report** ☒**Other (specify):**		
Triggering Action Date: October 25, 2000		
Due Date: December 19, 2005		

Five-Year Review Summary Form

Summary

No issues were identified that affected the ongoing protectiveness of the remedy. The following issues have been identified to ensure continued protectiveness.

Issues

Basin F Wastepile- Cell 2 of the primary sump system is not operating as designed. Very little leachate is being collected in Cell 2 of the primary sump (leachate collection) system while larger volumes are being collected by the secondary sump (leak detection) system. There is no evidence that the secondary system is leaking, but soils beneath the secondary sump will be monitored for staining during the Basin F Wastepile Excavation Project and reported in the CCR. It should be noted that the leachate and leak detection volume currently being generated, 25,641 gallons in calendar year 2004, has now leveled off after consistently and dramatically declining, (e.g., 24,650 gallons in calendar year 1999 and 81,336 gallons in calendar year 1990), due to dewatering of the waste. For those reasons, the issue is not affecting current protectiveness of the remedy.

Monitoring Well Maintenance and Security - During Five-Year Review (FYR) site inspections, four monitoring wells off-post, east of the north gate access to RMA and just outside the relocated fence, were found to be damaged and had not been fixed or replaced in a timely manner. Two of these wells were "orphan" wells that are not listed in the current database. The primary reason the monitoring wells were not locked was that the recent fence relocation resulted in on-post wells (for which locks are not required) now being located outside the secured perimeter fence. In addition, three other wells were identified which had previously been flagged in the database as requiring repair. Of the three wells, one was closed and replaced by a new well and the other two wells were repaired. The Army had scheduled these wells for repair prior to the FYR inspections and the repairs were completed after the site inspection was conducted. It is Army policy to lock all monitoring wells located outside the RMA perimeter fence or outside off-post fenced-in well fields. Also, the Well Retention and Closure Program requires prompt notification and response for damaged wells. This issue did not affect the protectiveness of the remedy.

Extraction Well and Extraction System Shut-Off Criteria- During the evaluation of how ROD shut-off criteria had been applied to past and planned extraction well and system shut-off, it became apparent that the existing ROD criteria leave room for interpretation. Two questions were identified related to the ROD shut-off criteria:

- When can a well be turned off for hydraulic purposes; can this apply when the well has already met chemical shut-off criteria?
- How long after an extraction well has been turned off for chemical purposes should shut-off monitoring start? (The ROD does not identify a timeframe for this action).

The possible interpretation differences of the ROD shut-off criteria have not affected the shut-off process during the past FYR period.

Establishing Site-Specific Practical Quantitation Limits- The On-Post ROD identifies the site-specific Practical Quantitation Limit (PQL) as "(c)urrent certified reporting limit or practical quantitation limit readily available from a commercial laboratory." The existing process for determining PQLs/MRLs has been identified as an issue for the compounds for which PQLs remain above the Containment System Remediation Goals/Colorado Basic Standards for Groundwater (CSRGs/CBSGs) in part because Army has used a MRL-based approach which differs from industry practice. The ongoing changes to the Army analytical programs and recent advancements in analytical technology suggest it would be beneficial to follow a standardized procedure to evaluate the analytical capabilities of several laboratories. Therefore, it has been determined necessary, during the next FYR period, to re-evaluate the current laboratory procedures and the procedure for establishing site-specific PQLs.

Institutional controls are in place to prevent exposure until the CSRGs/CBSGs are attained. The groundwater remedy as it currently exists is therefore protective.

Bedrock Ridge Plume Capture- As stated in the technical assessment, it was determined that a low volume of the Bedrock Ridge plume was not captured by the extraction system. To ensure that the ROD objective for this system was met, it was decided that the addition of an extraction well should be evaluated and tested. The additional extraction well was installed and its performance will be evaluated during the next FYR period.

While the need to improve plume capture was identified for the Bedrock Ridge System, the low volume of bypass did not affect remedy protectiveness due to site-wide remedy elements including downgradient groundwater treatment systems and institutional controls.

Shell Disposal Trenches Dewatering Goals- The ROD remedy for the Shell Disposal Trenches is described as "installing a soil cover and slurry wall to reduce movement of contaminants from the Shell Disposal Trenches in Section 36." Consistent with the assessment presented in the FYRR, the dewatering goal of achieving water levels below the bottom of the trenches had not been met at the end of the FYR period. The fact that water level measurements were not collected from the monitoring wells inside the slurry wall during part of the FYR period makes it difficult to verify that the remedy was functioning as intended. However, there is no impact to protectiveness due to site-wide remedy elements including downgradient groundwater treatment systems and institutional controls.

South Lakes Plume Management- The 2004 South Lakes Groundwater Monitoring Report concluded that there was no migration of groundwater contaminants into the South Lakes at levels exceeding CBSGs, and, consequently, the goal of preventing the migration of contaminants into the South Lakes has been met. As a result, , the parties agreed that it was appropriate to remove the lake level maintenance requirement related to plume management from the selected remedy in the On-Post ROD using an Explanation of Significant Differences (ESD), which was finalized in March 2006.

Off-Post Groundwater Intercept and Treatment System Performance Objectives Clarification- The OGITS was designed as and has been operated as a mass removal system. However, the use of containment terminology in descriptions of the system in several documents triggered comments regarding system performance and made it apparent that a clarification of system objectives was needed. The need to clarify the mass removal objective has not affected remedy protectiveness as the system has been operated as designed.

Northern Pathway System Modification- The property on which the Northern Pathway System (NPS) component of the OGITS is located was acquired by Amber Homes, Inc. Its plan for the property includes the development of a large retail center and residential areas that entail construction at the NPS location and its immediate surrounding area. The modifications to the OGITS affect the NPS extraction system and the associated recharge wells used for reinjection of treated groundwater are described in the Intermediate Conceptual Design Document by Amber Homes, Inc. The new NPS extraction wells will be operated concurrently with the original NPS extraction wells until the latter meet the shut-off criteria.

The system modification for the NPS was designed to meet or exceed the contaminant removal efficiencies of the original system. Also, the original system will continue to operate until shut-off criteria are met. The modification is therefore expected to have a positive impact on system effectiveness and maintain protectiveness. The construction of the NPS modification did not begin until November 2005 and had no impact on remedy protectiveness. No additional follow-up action is required beyond the follow-up action identified for the OGITS.

North Plants Fuel Release- Fuel contamination present as light nonaqueous phase liquid (LNAPL) was discovered in North Plants wells during the FYR period. As of the end of the FYR period, the need to perform additional characterization and/or remediation of the fuel contamination was being evaluated.

Changes in Monitoring Networks- Because of large-scale development and construction activities in the Off-Post OU, some Army monitoring wells have been destroyed and could not be re-drilled in the same locations. These unexpected changes to the off-post monitoring networks, along with the significant reductions in the extent of off-post contamination have resulted in a need to review and potentially revise the Off-post Exceeedance Monitoring Network which was last updated in 2003.

Operational Assessment Report Schedule (compared to schedule outlined in the Off-Post Remediation Scope and Schedule)- The Remediation Scope and Schedule for the Off-Post Operable Unit (RS/S) states that the Operational Assessment Reports (OARs) will be "published in the year following the reporting period." The OARs were not developed within the RS/S time requirement and concerns were raised by the Regulatory Agencies that delays in issuing the OARS prevent timely review and evaluation of remedy effectiveness. The OAR schedule delays may affect the ability to conduct timely reviews, but the delays did not affect remedy protectiveness as the information presented in the OARs is evaluated on a continuous basis by system operators and provided to the Regulatory Agencies in monthly status meetings.

State Engineer's Office Well Notification Program (Off-Post Institutional Controls)- The primary mechanism for implementing the institutional controls is a well notification program developed in conjunction with the Colorado Department of Natural Resources State Engineer's Office (SEO) and the Army. The Army prepares updates to a notification map and provides the map to the SEO for its use in notifying well permit applicants of their proximity to RMA groundwater contamination. After evaluation, Tri-County Health Department (TCHD) has concluded that the SEO is not including the agreed upon notification on all well permits issued in the notification area and copies of the permits are not routinely being transmitted to all parties. The inconsistency in notification has not resulted in the use of contaminated drinking water wells in the notification area.

While the Army has provided the SEO with all the necessary information to implement the off-post well notification program, the SEO has not been following the agreed-upon notification process. This issue needs to be addressed to ensure that this institutional control continues the *"(p)revention of the use of the groundwater underlying areas of the Off-Post OU exceeding groundwater containment system remediation goals."*

Recommendations and Follow-up Actions:

Basin F Wastepile- The On-Post ROD requires the Basin F Wastepile to be excavated and placed in an on-site triple-lined landfill, which began in the spring of 2006. Placement of all Basin F Wastepile material is currently scheduled to be completed by October 2008. There is no evidence that the secondary sump system of Cell #2 is leaking, but soils beneath the secondary sump system of Cell #2 will be monitored for leaks during the Basin F Wastepile Excavation Project and reported in the CCR. This action will address this issue which has not affected remedy protectiveness.

Monitoring Well Maintenance and Security- The Army will ensure that the well maintenance and security issues are corrected in accordance with Army policies and procedures in the next FYR period. Inspections of off-post and on-post monitoring wells will be conducted and reported in accordance with the revised Long-Term Groundwater Monitoring Plan (LTMP).

Extraction Well and Extraction System Shut-Off Criteria- Even though the Army concludes that this issue has not affected remedy protectiveness, more detailed and objective extraction well and system shut-off criteria will be proposed as part of revisions to the LTMP. Different shut-off criteria will be considered for the systems based on whether they are containment or mass removal systems and whether they are boundary or internal systems.

Establishing Site-Specific Practical Quantitation Limits- The Army recommends that the approach for establishing site-specific PQLs be revised and that a procedure for site-specific PQLs be developed. As of October 26, 2006, agreement has been reached with the Regulatory Agencies that PQL studies will be conducted in accordance with 40 Code of Federal Regulations (CFR) 136 Appendix B and soon-to-be published Colorado State PQL Guidance for compounds for which Method Reporting Limits (MRLs) exceed CSRGs, as outlined in Decision Document DD-RMAPQL-11. The site-specific PQLs determined from these studies will be implemented at RMA.

Bedrock Ridge Plume Capture- Based on monitoring and pumping tests in the Bedrock Ridge area, the Army recommended the addition of an extraction well to the Bedrock Ridge system to capture the flow of contaminated groundwater not previously captured by the system. The additional extraction well was installed in Fiscal Year (FY) 2005. Remedy performance will be monitored and assessed by the RMA Water Team during the next FYR period, to ensure remedy protectiveness is maintained.

Shell Disposal Trenches Dewatering Goals- The Army recommends that the dewatering goal of achieving water levels below the bottom of the trenches be evaluated after both the RCRA-equivalent cover and the adjacent soil covers have been installed at the Shell Disposal Trenches. This will allow meaningful assessment of the reduction of infiltration and lowering of groundwater levels in the Shell Trenches slurry wall enclosure caused by the cover systems. Water level monitoring will be performed and documented.

South Lakes Plume Management- The 2004 South Lakes Groundwater Monitoring Report, concluded that there was no migration of contaminants into the South Lakes at levels exceeding CBSGs which addressed the concern presented in the ROD. Consequently, the parties agreed that it was appropriate to remove the lake level maintenance requirement pertaining to plume management from the selected remedy in the On-Post ROD using an ESD. The ESD was approved by EPA on March 31, 2006.

As a separate part of the remedy, the Interim Institutional Control Plan has established lake level performance criteria for the future, but only for the remaining human health exceedance (HHE) soil and aquatic ecosystems ROD requirements of maintaining a healthy aquatic ecosystem and preventing human exposure to potentially contaminated sediments, respectively.

Off-Post Groundwater Intercept and Treatment System Performance Objectives Clarification- This FYRR clarifies that the OGITS has been and will continue to be operated as a mass removal system in accordance with the design and ROD documentation. The revised LTMP will provide specific performance criteria for evaluation of system mass removal effectiveness to facilitate future system evaluations presented in the OARs and conducted as part of FYRs. The Army believes that the need to clarify the overall remedial objectives of the system has not affected system operation or protectiveness of the remedy during the FYR period.

Northern Pathway System Modification -The Army proceeded with the modifications to the NPS component of the OGITS in 2005. It is anticipated that the modifications will increase the system's mass removal effectiveness and expedite the cleanup of the Off-Post OU. The performance of the modified NPS will be monitored during the next FYR period.

North Plants Fuel Release- Fuel remains as LNAPL in the North Plants vicinity. The LNAPL will be evaluated in accordance with applicable requirements during the next FYR period.

Changes in Monitoring Networks- Even though the Army has concluded that this issue has not affected remedy protectiveness, a revised LTMP will be issued in 2007. All monitoring categories and containment and treatment systems identified in the 1999 LTMP and the 2003 Well Retention and Closure Program will be evaluated.

Operational Assessment Report Schedule- Even though the Army has concluded that this issue has not affected remedy protectiveness, the Army will ensure that the OAR schedule provided in the Off-Post RS/S be adhered to, starting with the 2005 OAR, which was issued in September 2006.

State Engineer's Office Well Notification Program (Off-Post Institutional Controls- The TCHD has agreed to conduct more stringent SEO oversight to ensure that the well notification program is adhered to in the future.

Protectiveness Statements:

The protection of human health and the environment of the remedial actions at both the On-Post and Off-Post OUs are discussed below. All controls are in place to adequately minimize risks. Because the remedial actions at both the On-Post and Off-Post OUs are expected to be protective of human health and the environment upon completion, the remedy for the entire site is expected to be protective of both human health and the environment.

On-Post OU- The Army has concluded that the remedy at the On-Post OU is expected to be protective upon completion or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. All immediate threats have been adequately addressed in the form of IRA and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the On-Post ROD, as appropriate. The HWL and ELF, which are central to the effective implementation of the remedy, have been expeditiously constructed and are operational. All other implementation projects are on schedule and in compliance with all elements of the On-Post ROD. Air, water, and biota monitoring programs are comprehensive in their design and effective in their implementation. Contaminant migration is being adequately controlled. Risks to human health and the environment are also being controlled by completion of remedial action, by a comprehensive worker protection and access control programs, by institutional controls and by implementation of IRAs.

Off-Post OU- The Army has concluded that the remedy at the Off-Post OU is expected to be protective upon completion or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. All immediate threats have been adequately addressed in the form of IRAs and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the Off-Post ROD, as appropriate. Administrative controls to protect the public have been effective in their implementation. Groundwater contamination is being treated to ROD remediation goals at both the RMA boundary systems and the OGITS.

1.0 INTRODUCTION

Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986, together with the implementing regulation in the National Oil and Hazardous Substance Pollution Contingency Plan, requires that remedial actions resulting in any hazardous substances, pollutants, or contamination remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to assure protection of human health and the environment. This requirement applies to RMA and, consequently, this report documents the 2005 FYR.

The RMA 2005 FYR was conducted by the Army in accordance with Paragraph 36.3 of the FFA and CERCLA, Section 121(c).

The RMA 2000 FYR of CERCLA remedial actions covered the period December 19, 1995 through March 31, 2000. This report documents the RMA 2005 FYR, which covers the period April 1, 2000 through March 31, 2005. Environmental monitoring and analytical data results from October 1, 1999 through September 30, 2004 were considered in this FYR. Changes in laws, applicable or relevant and appropriate requirements (ARARs) and to-be-considered criteria (TBCs) between April 1, 2000 and March 31, 2005 are included in this FYR. Construction Completion Reports (CCRs) approved by the U.S. Environmental Protection Agency (EPA) between April 1, 2000 and March 31, 2005 are considered "completed projects" for this FYR. In fact, all projects are organized based upon their status as of March 31, 2005.

It should be noted, that as a complex site, this RMA FYR required extensive research over an extended period of time. Where data and information relevant to preparation of the FYRR, or necessary for response to Regulatory Agency comments became available after the deadlines noted above, it was evaluated for inclusion. Subsequent data and reports were included whenever the information was important to the assessment. In addition, general status information was updated beyond the deadlines enumerated above to make the FYRR more understandable and useful to the reader.

The purpose of the FYR is to determine whether the remedy for RMA selected in the On-Post and Off-Post RODs remains protective of human health and the environment. For elements of the remedy that are under construction, or have not yet begun, the purpose of the review is to confirm that immediate threats have been addressed. The FYRR provides a detailed discussion of the conclusions reached and recommendations made.

EPA guidance requires FYRs to be conducted site-wide. For the RMA, this includes the On-Post OU, the Off-Post OU, and all IRAs implemented prior to the signing of the RODs. The review of the IRAs, the On-Post OU, and the Off-Post OU is required by statute. The schedule for conducting this FYR is based upon the signature of the Off-Post ROD on December 19, 1995.

Due to the size and complexity of the RMA site, and to keep this report as clear and readable as possible, other documents are routinely referenced as sources for more detailed information. In addition, every effort has been made to cross-reference to other parts of the FYRR where the topic is addressed further.

The general structure of this report was based on current EPA FYR Guidance (EPA 2001a). To enable the reader to better understand this report, the following outline is provided.

Section 1.0 Introduction – Provides the legal basis and the objectives for the review as well as description of the report structure.

Section 2.0 Site Chronology – Provides a chronology of significant ROD-related events.

Section 3.0 Background – Provides historical information on RMA including a description of past operations, a list of contaminants of concern (COCs), and information on current and future land use.

Section 4.0 Remedial Actions – To streamline the presentation of information, this section is first organized to be consistent with the selected remedy in the On-Post and Off-Post RODs. This approach helps streamline the presentation of the Remedial Action Objectives (RAOs), the selected remedy, the ROD standards and the ROD goals. To accomplish this, the implementation projects are first grouped in Section 4 into one of three ROD medium groups (groundwater, soil, structures) or "other" for miscellaneous remedy components.

Consistent with EPA FYR guidance, within the three medium groups or "other", the projects are further grouped into projects under construction, operational projects and completed projects. This second structure facilitates organization of the assessments in Section 7.0.

Section 5.0 Progress Since First Review – Includes the protectiveness statements and lists the status of recommendations and follow-up actions from the 2000 FYRR and whether they achieved the intended purpose.

Section 6.0 Five-Year Review Process – Provides a list of participants in the FYR process as well as the approach taken in performing this review. This section also presents data collected in the groundwater, surface water, biota, and air monitoring programs, and a section summarizing remedy costs.

Section 7.0 Assessment – Uses information provided in Section 6.0 as well as additional information gathered in the review process to answer three key questions. Consistent with EPA FYR Guidance, the projects are regrouped in Section 7.0 into projects under construction, operational projects and completed projects to facilitate the assessment process.

Section 7.1 through 7.3– Answers the question "(i)s the remedy functioning as intended by the decision documents?"

Section 7.4 – Answers the question "(a)re the assumptions used at the time of the remedy selection still valid?" This includes a review of risk assessment assumptions, an update to all ARARs, standards, and TBCs., and a discussion of the impact of these changes.

Section 7.5 – Answers the question "(h)as any other new information come to light that could call into question the protectiveness of the remedy."

Section 7.6 – Provides a Technical Assessment Summary.

Section 8.0 Issues – Provides a succinct statement of the issues.

Section 9.0 Recommendations and Follow-up Actions – Details follow-up actions necessary to address the Issues identified in Section 8.0.

Section 10.0 Protectiveness Statements – Provides protectiveness statements under the current FYR for both the On-Post and Off-Post OUs.

Section 11.0 Next Five-Year Review – Details when the next FYR is scheduled to take place.

Section 12.0 References

2.0 SITE CHRONOLOGY

Table 2.0-1 lists the chronology of significant ROD-related events. Additional information regarding the schedules of specific remedial projects start and completion dates and CCR dates are presented in Table 2.0-2, the Remediation Design and Implementation Schedule (RDIS)(PMRMA 2004a) and in the CCRs listed in the references.

2.1 Deletions from the National Priorities List

As of the date of issuance of the FYRR four partial deletions have occurred and include the Western Tier Parcel, the Selected Perimeter Area, the Surface Deletion Area and the Internal Parcel Area. Combined these four deletions have reduced the area remaining on the NPL to approximately 5.5 square miles.

2.1.1 Western Tier Parcel

The Refuge Act stipulates that approximately 815 acres (later more accurately defined as 917 acres), referred to as the Western Tier Parcel will be transferred to Commerce City for fair market value. The first step in the process was the partial deletion of the Western Tier Parcel from the NPL. In October 1998 a Notice of Intent for Partial Deletion (NOIDp) was published by EPA in the Federal Register. The deletion was subsequently postponed to allow for additional soil sampling. During the soil sampling, a site reconnaissance was performed that identified eight areas requiring subsurface investigation. The investigation resulted in excavation of one of the eight areas. Concurrently, site-wide evaluation of potential UXO and recovered chemical warfare materiel (RCWM) was being conducted in response to the discovery of chemical warfare agent-filled bomblets elsewhere at the site. This evaluation is discussed further in Section 4.5.1.3. These additional efforts resulted in the publication of a second NOIDp in September 2002. After public comment, the Notice of Partial Deletion (NODp) was published in January 2003. The ultimate sale of the property to Commerce City occurred in June 2004.

2.1.2 Selected Perimeter Area and Surface Deletion Area

The Refuge Act also requires that upon certification by EPA that all response actions at RMA have occurred (NPL deletion) the Army will transfer administrative jurisdiction over the property to the USFWS. The Army first proposed deletion of the perimeter area in 1999, but the effort was suspended as a result of the bomblet discovery noted above. Once the site-wide evaluation of UXO and RCWM was complete, Perimeter Deletion efforts resumed, resulting in two NOIDps (Selected Perimeter Area and Surface Deletion Area) being published in the Federal Register in July 2003 for a total of approximately 5,000 acres. The corresponding NODps were published in the Federal Register in January 2004. The Selected Perimeter Area and Surface Deletion Area were transferred to the USFWS on March 2, 2004, and the USFWS officially established the Rocky Mountain Arsenal National Wildlife Refuge in April 2004.

The Refuge Act also specifies that 100-foot (ft.) wide strips inside the RMA boundary on the northwest, northern, and southern sides be transferred to local governments, at no cost, to allow improvement of public roads. The approximately 11 miles of 100-ft. wide strips amount to approximately 126 acres. This property was included in the Selected Perimeter Area Deletion described above. Following that deletion, the property was transferred to the units of local government in September 2004.

2.1.3 Internal Parcel

As continuation of efforts started in the Selected Perimeter Area deletion, a NOIDp for the Internal Parcel at RMA was published in April 2006. Following public comment, the NODp for approximately 7,400 acres (11.5 square miles) was published at the end of July 2006. Most of the property was transferred to the USFWS in September 2006 to further expand the Refuge.

3.0 BACKGROUND

The RMA site is comprised of two OUs. The On-Post OU consists of all of RMA and occupies approximately 17.2 square miles in southern Adams County, approximately 10 miles northeast of downtown Denver. The Off-Post OU encompasses groundwater CSRG exceedance areas which underlie approximately 2.4 square miles of rural, agricultural, commercial, residential, and industrial-zoned areas north and northwest of RMA as well as property where the OGITS is located The Off-Post and On-Post OUs are depicted on Figure 3.0-1.

The Army established RMA in 1942 to produce chemical warfare agents and incendiary munitions used in World War II. Following the war and through the early 1980s, the Army continued to use these facilities. Beginning in 1946, some RMA facilities were leased to private companies to manufacture industrial and agricultural chemicals. Shell, the principal lessee, manufactured primarily pesticides at RMA from 1952 to 1982. Common industrial and waste disposal practices during these years resulted in the release of contamination. Approximately 70 chemicals have been the focus of the RI for the On-Post OU. Of these, the principal contaminants are OCPs, heavy metals, agent-degradation products and manufacturing by-products, and chlorinated and aromatic solvents. The specific COCs that were identified for on-post soil and off-post groundwater are listed in Table 3.0-1. The individual CCRs may be referenced for a list of COCs on a project-specific basis.

The RI and subsequent investigations have identified more than 180 sites with contaminated soil, ditches, stream and lakebed sediments, sewers, groundwater, surface water, and structures. These contaminated areas included approximately 3,000 acres of soil, 15 groundwater plumes, and 798 structures. Sites that posed potential immediate risks to human health and the environment were addressed through IRAs.

Groundwater contamination migrated off-post prior to the implementation of groundwater pump and treatment systems, resulting in the necessity for establishing and investigating the Off-Post OU. Specifically, the Off-Post OU addressed groundwater contamination north and northwest of RMA. The risk assessment performed for the Off-Post OU indicated that the only exposure pathway of concern was human exposure to contaminated groundwater.

IRAs were determined to be necessary to mitigate the impact of contamination at several sites prior to selection of a final remedy. These interim actions are described in the IRA Summary Reports discussed in the 2000 FYRR (PMRMA 2000a). Most of these actions were completed before the RODs were issued, although some are ongoing (e.g., groundwater treatment systems) and have been incorporated into the RODs. All interim actions necessary to mitigate immediate risks have been implemented and those that are ongoing have been incorporated into ROD-mandated projects and are evaluated in that context.

Because the area is ecologically unique, current and future land use for the On-Post OU has been restricted pursuant to land use restrictions established by the FFA. Surrounded by development, the RMA provides a refuge for an abundant diversity of flora and fauna. For this reason the site has been designated as a future national wildlife refuge by the Refuge Act. As components of the remedy are completed and the land is deleted from the NPL, administrative jurisdiction will be transferred to the USFWS, except for the property and facilities continuing to be used for response actions (e.g., landfills and groundwater treatment systems).

Refuge property must be managed in accordance with the Refuge Act. The land transferred or sold to other non-USFWS parties continues to be subject to restrictions prohibiting residential and industrial use, use of water on the site as a source of potable water, hunting and fishing for consumptive use, and agricultural use in accordance with the On-Post ROD, the Refuge Act, and the FFA. Current and future land use of the Off-Post OU has not been restricted, though the permitting of new groundwater well use has been regulated through a series of institutional controls identified in the Off-Post ROD and assessed in Section 7.2.2.3.

4.0 REMEDIAL ACTIONS

This section presents the remedy selected in the ROD, administrative changes to the ROD and the status of each component of the ROD. The On-Post ROD specified that the remedy address four essential parts: groundwater, structures, soil, and "other". These are described below. The four parts and their components were reconfigured into a design/construction-oriented approach as detailed in the RDIS.

Table 2.0-2 provides a detailed list of the On-Post and Off-Post ROD projects/topics and the IRAs and the Section numbers where each project/topic is discussed in the FYRR. The number in each section heading (e.g., #17) also allows cross reference to Table 2.0-2.

Table 2.0-2 is keyed to the list of projects provided in the Table of Contents to Appendix B of the RDIS and includes project name, status of each project as of March 31, 2005, and forecasted start and CCR completion dates for each project. Projects that have not yet begun have forecasted start dates. More detailed information on the schedule of each project as well as a more comprehensive description can be found in the RDIS for On-Post ROD projects, the RS/S for Off-Post ROD projects, and the IRA Summary Reports.

Consistent with EPA FYR Guidance the status of each project is defined by one of the following:

- **Not yet begun** - Defined as "in the planning stages and prior to completion of the 100 Percent Design on of March 31, 2005."
- **Under construction** - Defined as "having an approved 100 Percent Design prior to or on March 31, 2005, but not yet having an approved CCR prior to or on March 31, 2005."
- **Operating** - Defined as "a fully operational project."
- **Completed** - Defined as "having an approved final CCR or IRA Summary Report prior to or on March 31, 2005".
- **Transferred** - Applicable to IRAs, defined as "a project closed out with elements transferred administratively into a specific, related ROD-identified project."

Consistent with Table 2.0-2, Figure 4.0-1 through Figure 4.0-5 depict: 1) the locations of the completed remedy projects discussed in the 2000 FYRR; 2) projects not yet begun as of March 31, 2005; 3) projects under construction as of March 31, 2005; 4) operational projects as of March 31, 2005; and 5) completed projects as of March 31, 2005, respectively. Note that the projects in these five figures are also cross-referenced by number to Table 2.0-2.

4.1 On-Post OU Groundwater Remedy Selection and Implementation

The On-Post ROD specified the following RAOs for groundwater:

> "E*nsure that the boundary containment and treatment systems protect groundwater quality off-post by treating groundwater flowing off RMA to the specific remediation goals identified for each of the boundary systems.*
>
> *Develop on-post groundwater extraction /treatment alternatives that establish hydrologic conditions consistent with the preferred soil alternatives and also provide long-term improvement in the performance of the boundary control systems."*

The selected remedy for On-Post groundwater includes:

> *"Operation of all existing boundary systems and on-post groundwater IRA systems, installation of a new extraction and piping system, and development of an extended monitoring program. ... The systems will be operated until shut-off criteria as described below, are met.*
>
> *Existing wells within the boundary and off-post containment systems can be removed from production when concentrations of constituents detected in the well are less than the ARARs listed in Appendix A and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems as identified by*

the remediation goals described above and the CSRGs listed in Tables 9.1-1, 9.1-2, and 9.1-3. Wells removed from production and monitoring wells upgradient and downgradient of the boundary and off-post containment systems will be monitored quarterly for a period of 5 years to determine whether contaminants have reappeared; however, those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Boundary and off-post containment system extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required.

Existing wells within the internal containment systems can be removed from production when concentrations of constituents detected in the wells are less than ARARs listed in Appendix A and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems as identified by the CSRGs listed in Table 9.1-4. Wells removed from production and monitoring wells upgradient and downgradient of the internal containment systems will be monitored quarterly for a period of 5 years to determine whether contaminants have reappeared; however, those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Internal containment system extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required."

Other specific components of the selected remedy for On-Post groundwater are provided below in the context of the project discussions.

4.1.1 On-Post Groundwater Remedy Under Construction

4.1.1.1 Section 36 Bedrock Ridge Groundwater Barrier Plume Extraction System #28

The selected remedy in the On-Post ROD for the Section 36 Bedrock Ridge Groundwater Plume Extraction System requires:

> *"A new extraction system will be installed in the Section 36 Bedrock Ridge area. Extracted water will be piped to the Basin A Neck system for treatment (e.g., by air stripping or carbon adsorption)."*

The Bedrock Ridge extraction system was installed in 2000. Continuous evaluation of the Bedrock Ridge extraction system during this FYR period led to the decision to modify the system to improve plume capture. The data that formed the basis for this conclusion were presented to the Regulatory Agencies during Water Team meetings throughout 2003 and discussed in the 2003 and 2004 OARs (PMRMA 2005b, 2005c).. The decisions to perform pumping tests and to add an extraction well were made in agreement with representatives from the Regulatory Agencies in a meeting on June 11, 2003. Monitoring Well 36557 was used temporarily as an extraction well during 2004 to enhance capture of the Bedrock Ridge plume and determine the feasibility of adding a permanent extraction well at this location. Pumping of this well successfully captured the plume in this area. Consequently, the Remediation Venture Office (RVO) proceeded with installing the permanent extraction well. Extraction Well 36306 was installed and became operational after the end of the current FYR period and its effectiveness will be addressed in subsequent OARs and in the next FYRR. The extended evaluation of these system became necessary when bomblets were discovered in the vicinity.

During preparation of and resolution of comments on the 2005 FYRR, an ESD was prepared documenting a cost change for the project (WGI 2006). The ROD cost was originally estimated based on installation of a 1,400-foot long horizontal well for plume capture. Design studies indicated that the plume was narrower than anticipated and the horizontal well was replaced with three vertical extraction wells. The fourth extraction well was added in 2005 as discussed above. The change in well configuration resulted in a 66 percent decrease in the overall cost compared to the ROD estimate. EPA approved the ESD on May 4, 2006.

A final CCR for this project is in preparation and will include an analysis of whether the system is operating properly and successfully.

4.1.2 Operating On-Post Groundwater Remedies

The RMA groundwater containment and treatment systems are identified in Figure 4.1.2-1. The operation of these systems is addressed in detail in the OARs (PMRMA 2005a, 2005b, 2005c, 2004b, 2003a, 2003b, 2003c, 2002a, 2002b, 2002c, 2001a, RVO 2004a, 2003a).

Operation and maintenance (O&M) cost for the systems have been included in the OARs since 2002. The costs presented in the OARs are based upon all field costs including utilities and analytical support. The treatment plant O&M costs over this FYR period have fluctuated within expected limits; there are no obvious upward or downward cost trends. The largest normal fluctuation in costs from year to year is based on changes in lab and sampling costs. As discussed in the annual OARs, there were several maintenance actions that caused short duration cost increases. The notable increases are as follows:

- <u>Basin A Neck Containment System</u> During 2004 two modifications were made to the existing plant to support ongoing O&M. First the air stripper for the plant was relocated to the plant head works to allow for treatment of the entire plant flow as documented in Washington Group Design Change Notice (DCN) 2, Work Order # 4759-154. Additional recharge trenches were constructed to enhance the plant's overall treatment capacity as documented in Washington Group's DCN 3, Rev. 2, Work Order # 4759-154.

- <u>Irondale (Railyard) Containment System</u> During 2001 treatment of the Railyard Area flow was transferred from the oversized Irondale treatment plant to the Railyard Treatment plant. The relocation of the flow and design of the Railyard system was documented in the design.

4.1.2.1 Shell Disposal Trenches Slurry Walls (dewatering) #17

The selected remedy in the On-Post ROD for the Shell Disposal Trenches Slurry Walls requires:

> *"Expansion of the existing slurry wall around the trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be re-evaluated during remedial design."*

The Shell Disposal Trenches Slurry Walls remedy includes installation of a slurry wall encircling the disposal trenches as shown in Figure 4.1.2.1-1. Figure 4.1.2.1-1 also depicts groundwater elevations. The 2-ft thick slurry wall, installed in 1998, surrounds the 6-inch thick slurry wall installed in 1991.

The purpose of groundwater level monitoring, specified in the combined Complex (Army) Trenches and Shell Section 36 Trenches design (RVO 1997a), is to measure water level differentials across the barrier wall to obtain information on the direction (i.e., inward or outward) of gradients across the barrier. Monitoring is also conducted to obtain information on the water level differentials that could potentially affect barrier wall stability. The design document stated that dewatering inside the slurry wall was not necessary since water levels were already below the bottom of the trenches. As such, the dewatering goal was redefined as "lowering the water table below the trench bottom." Prior to the construction of the Shell Disposal Trenches Slurry Wall in 1998, 10 existing monitoring wells adjacent to the slurry wall alignment were cut off and capped. Nine of the 10 wells were rehabilitated. Monitoring Well 36534, was damaged beyond repair, and since this well had been dry historically, it was not replaced.

Groundwater level measurements were not collected for the ten wells inside the slurry wall from January 2000 to July 2003 during the FYR period due to an oversight. Consequently, assessment of the performance of the slurry wall during the FYR period is based on limited data.

The improved effectiveness of the ROD slurry wall compared to the IRA slurry wall is demonstrated by a reduction in the northerly hydraulic gradient inside the slurry-wall enclosure and larger head differences across the slurry wall on the north side, especially at the northeast corner where leakage of the IRA slurry wall was suspected. Between 1997 (before the ROD slurry wall was constructed) and 2005, the northerly gradient has decreased from 0.0047 ft./ft. to 0.0018 ft./ft. (62 percent reduction) on the west side and from 0.015 ft./ft. to 0.010 ft./ft. (33 percent reduction) on the east side. The higher gradient on the east side is caused by the presence of a low permeability clay unit in the alluvium, whereas the alluvium is composed of more permeable sand on the west side.

In the northeast corner, the head difference was only 0.23 ft. in December 1997 before the ROD slurry wall was constructed; it was up to 1.4 ft. in December 2003 when an outward gradient was present, and was 4.2 ft. in December 2004 when an inward gradient was present. Fluctuating water levels outside the slurry wall due to infiltration of precipitation caused the gradient direction to change.

During the FYR period, the hydraulic gradient direction was as follows: inward at the southwest and northeast corners, and either inward or outward at different times in the southeast and northwest corners and the north central monitoring location. Since dewatering is not required, creating or maintaining an inward hydraulic gradient also is not required. The maximum hydraulic gradient across the slurry wall was 3.09 ft./ft., which is well below the upper safe limit of 10 ft./ft.

Based on available water-level data, it appears that the groundwater elevations have remained below the bottom of the trenches except at one location. This is based on six borings where the trench bottom elevations were determined during the RI (see Table 4.1.2.1-1), and the groundwater elevations were lower at five of the six locations during this FYR period.

In June 2005, Well 36536, located inside the slurry-wall enclosure at the southwest corner, contained sediment in the bottom of the well and the water level could not be measured. It was cleaned out in July 2005 to better evaluate the water elevation inside the slurry-wall enclosure. The water levels were measured in September 2005, after the end of the current FYR period. Linear interpolation of water table contours between Well 36529 and 36536, indicates the water table elevation was above the trench bottom in one of the six borings (boring 3453) by approximately 1 ft. (Figure 4.1.2.1-1). The September 2005 water elevation in Well 36536 is approximately one ft. higher than in early 1998 when water elevations could last be obtained. A rise in water levels in this well could be caused by infiltration of precipitation inside the slurry-wall enclosure and/or additional flow into the enclosure.

Well 36537 is located between the two slurry walls as shown on Figure 4.1.2.1-1. Figure 4.1.2.1-2 shows that after the ROD slurry wall was installed in 1998, when Wells 36536 and 36537 both contained water, their elevations were very similar. Linear data interpolation for elevation contouring between Wells 36529 and 36536, using the same water levels for Wells 36536 and 36537, indicate that the water elevation at Boring 3453 likely was above the trench bottom during part of the FYR period (i.e., in December 2004 and February 2005), but likely was below the trench bottom from July 2003 through September 2004.

The water elevation in Well 36226, which is located near Wells 36536 and 36537, but outside the ROD slurry wall, rose about 5 ft. in 2004 (Figure 4.1.2.1-2), which likely is due to localized recharge caused by infiltration of precipitation. A similar rise in water levels was not observed in upgradient Well 36087 (shown on Figures 4.1.2.1-1 and 4.1.22.1-2), which supports a localized recharge explanation for Well 36226. Therefore, either infiltration of precipitation occurred inside the slurry-wall enclosure and/or the higher water levels in Well 36226 caused a higher gradient across the slurry wall and additional flow into the slurry-wall enclosure, potentially causing the higher water levels in Wells 36536 and 36537. Water levels in all three wells have since declined (Figure 4.1.2.1-2).

The ROD goals for the Shell Disposal Trenches are "(m)inimize groundwater flow across the slurry wall with a design goal of 1×10^{-7} cm/sec hydraulic conductivity" and "(d)ewater as necessary to ensure containment." The information provided above indicates that the ROD slurry wall is more effective than the IRA slurry wall, and meets the ROD goals, including containment. The concept of lowering the water levels below the disposal trenches is not a ROD requirement, but was added in the design document; however, the design document determined that the groundwater was already below the trenches, so dewatering was unnecessary. The apparent elevated water table in one boring in December 2004, and February and September 2005 is likely related to recent infiltration of precipitation. This situation should be evaluated further during the next FYR period and a decision about the potential need for dewatering inside the slurry-wall enclosure should be deferred until after the remedy is complete (i.e., the Resource Conservation and Recovery Act (RCRA) equivalent and soil covers are installed in South Plants, Basin A, and the Shell Disposal Trenches), and their effects on reducing infiltration of precipitation, recharge of groundwater, and lowering of water levels inside the Shell Disposal Trenches slurry-wall enclosure are evaluated.

4.1.2.2 Complex (Army) Disposal Trenches Slurry Walls (dewatering) #17

The selected remedy in the On-Post ROD for the Complex (Army) Disposal Trenches Slurry Walls requires:

> *"Installation of a slurry wall into competent bedrock around the disposal trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be re-evaluated during remedial design."*

Installation of the Complex (Army) Disposal Trenches slurry wall began in 1998 and the project was completed in 2000. Testing of the groundwater extraction trench was completed in February 2000 and operation of the dewatering system began in March 2001.

For the Complex (Army) Disposal Trenches, the head differential across the groundwater barrier is monitored to ensure that the groundwater extraction system does not induce differentials that would potentially affect barrier wall stability. Also, for compliance purposes, water levels adjacent to disposal trenches will be monitored to confirm the dewatering objective of lowering the water table below the bottom of these trenches that was identified in the *Complex Trenches and Shell Section 36 Trenches Groundwater Barrier Project 100% Design* (RVO 1997a). The design dewatering goal is derived from the On-Post ROD goal (FWENC 1996) of "dewater as necessary to ensure containment."

The maximum hydraulic gradient across the barrier wall during the second FYR period was 3.4 ft./ft., which is well below the upper safe limit of 10 ft./ft. cited in the Design Document. An inward hydraulic gradient was also present at the two well pairs adjacent to the slurry wall. Maintenance of an inward gradient indicates that containment has been achieved at the slurry wall as required by the ROD.

The Design Document specified that the water levels should be lowered to below the trench bottoms and estimated from groundwater modeling results that the groundwater levels would be lowered sufficiently to achieve the dewatering goal in five years or less at a continuous pumping rate of 2 gallons per minute (gpm) based on the water levels that existed in 1996 and other specific conditions assumed in the model. More information concerning the groundwater model predictions is provided in Appendix B. System operation data from March 2001 through August 2002 were evaluated in the *Complex Army Trenches Groundwater Barrier Project Groundwater Extraction System Operational and Functional Report* (FWENC 2001a). The data and analysis indicated that at the design flow rate of 3 gpm the water levels rapidly approached the target groundwater elevations in 2002. The report stated, "(t)his appears to indicate that the design flow rate is conservatively high, which is consistent with the design document." The report also states, "[the figures presented in the report] show that the target elevations likely would have been reached during 2002 if the flow rate had been maintained at 3 gpm." These conclusions only apply to the first year and a half of operation, however, and are not representative of the entire FYR period because 2002 was a severe drought year in which the annual precipitation was only 55 percent of normal. The report stated that short-term increases in groundwater elevations, in response to precipitation events, occurred in 2001 and may occur in the future until the RCRA-equivalent cap is installed. After 2002, the annual precipitation returned to normal and the decline is water elevations slowed in response to the associated increase in recharge. Apparently, during 2002 the actual recharge was less than was assumed in the groundwater model, and after 2002 the actual recharge was more than was assumed in the model.

A summary of the operational data for the FYR period is provided below, and more details are provided in Appendix B. Water levels in the two dewatering goal compliance wells have dropped 3 to 6 ft. since dewatering commenced. The water level in Well 36216 has remained below its target elevation starting in July 2004 (Figure 4.1.2.2-1). Well 36217 has remained above its target elevation throughout the FYR period (Figure 4.1.2.2-2). The dewatering goal was nearly attained in Well 36217, however, because the water elevation came within 0.3 feet of the target elevation. From March 2001 through 2002, the dewatering well pumping rate averaged 1.3 gpm (i.e., 35% less than the 2 gpm in the model simulations). Even with the low pumping rate, water levels fell rapidly and almost met the dewatering goals during the 2002 drought, indicating that when recharge is minimal (as will be the case when RCRA-equivalent covers are in place), pumping only 1.3 gpm can probably meet the dewatering goals. With the return to normal annual precipitation, and sometimes unusually high monthly precipitation after 2002, the downward trend in water levels in Well 36217 stopped just before reaching the water-level goal. Since 2002, the average flow rate was higher (1.6 gpm), but the water levels in Well 36217 have remained above the goal and fluctuated seasonally, usually within 1 foot of the goal, because of the additional infiltration of precipitation and recharge. Drawdown in Well 36217 was less than in Well 36216, as predicted by the modeling. Although the dewatering goal was not met in one of the compliance wells, the drawdown exceeds the amount of drawdown that was estimated to be required to meet the goals in the 100% Design Document in 1997. Since water levels prior to startup (i.e., in March 2001) were higher than the initial water levels used in the modeling (i.e., water levels in 1996), additional drawdown is still needed to meet water-table elevation goals in one of the two compliance wells.

For the FYR evaluation, it is appropriate to compare the actual dewatering-well flow rate to the design flow rate of 3 gpm. Figure 4.1.2.2-3 shows the daily flow rate of the dewatering well 36305 during the FYR period. This graph shows that the system was not pumped at the design pumping rate of 3 gpm for most of the FYR period. In some cases, operational limitations at the Basin A Neck Containment System (BANCS) were responsible for not attaining the design flow rate. These limitations involved biofouling of the recharge trenches and concerns about causing additional plugging of the recharge trenches by treating a higher flow rate from the Complex (Army) Trenches. The Complex (Army) Trenches groundwater contains high concentrations of manganese. The groundwater flow from Basin A also has high manganese concentrations, and over time, manganese bacteria had caused plugging in the BANCS recharge trenches such that there was very little available recharge capacity in 2001 when the Complex (Army) Trenches system started up. At startup of the system, the initial flow rate of 0.7 gpm was lower than the design flow rate of 3 gpm because of fouling of the piping and air stripper with a manganese precipitate, and because of the potential to increase the plugging of the recharge trenches if a higher flow rate would have been used. Due to this biological fouling of the BANCS recharge trenches (A, B, and C) by manganese bacteria, two new trenches (D and E) were constructed in 2004. The air stripper also was replaced in 2004 and now treats all the flow through the treatment plant instead of just a sidestream (formerly from the North of Basin F Extraction Well). The new air stripper provided an added benefit in that it reduced the biofouling of the recharge trenches and some of the capacity in the trenches was regained. Thus, the recharge capacity limitations and treatment concerns were resolved in 2004. Replacement of the air stripper was documented in BANCS DCN # 2 (WGI 2003a), and installation of the supplemental recharge trenches was documented in a Memorandum of Record (RVO 2004b) and BANCS DCN #3, Rev.2 (WGI 2004).

More recently, in 2005, the flow rate has decreased because of falling water levels in the dewatering trench and well. Figure 4.1.2.2-4 shows the water elevations in the dewatering well during the FYR period, including the significant decline of about 6 ft. in 2005. The flow rate was reduced from 3 gpm to between 2.0 and 2.5 gpm in February 2005 because water-level declines in and near the dewatering trench caused frequent on-and-off cycling of the well pump. Due to these factors, the dewatering system was operated at the design flow rate for only a small portion of the FYR period; yet, the dewatering goals were nearly achieved.

Dewatering will continue until water levels are below the target elevations in both compliance wells, and a sufficiently large area within the barrier has been dewatered such that water levels cannot rise above the target elevations when the dewatering system is turned off. However, it is believed that this is not likely to occur until after the RCRA-equivalent cover has been installed. In a flow rate analysis of testing of the dewatering trench that was presented in the Complex (Army) Disposal Trenches Groundwater Barrier Project CCR, (FWENC 2001b) it is stated, "(i)t should be recognized that lowering the water table in the vicinity of the Complex (Army) Disposal Trenches may be difficult until the RCRA-equivalent cover is constructed over the area, thereby essentially eliminating surface recharge." The CCR went on to say that, "(t)he effectiveness of the groundwater extraction system will be evaluated after the cap has been installed, reducing surface water recharge of the trench area. Compliance with the ROD goal (actually the Design Document goal) of dewatering the Complex (Army) Disposal Trenches will be revisited after the cap has been completed and the extraction system is operational." Although these statements were made prior to startup of the dewatering system, the CCR attempted to clarify when the dewatering goals might be achieved, and recognized that until recharge is reduced after the RCRA-equivalent cover is installed, it would be difficult to achieve the dewatering goals. The operational data presented herein have confirmed these statements in the CCR.

The RVO has attempted to meet the design flow rate of 3 gpm or maximize the rate when 3 gpm could not be achieved during the FYR period. The decline in water levels near the end of the FYR period shown in Figure 4.1.2.2-4 may indicate that dewatering is successfully occurring, but may also indicate a reduction in the capacity of the dewatering well or trench. Since the decline in the water levels occurred at the end of the FYR period, it will be necessary to evaluate the system performance during the next FYR period when more data are available. The operational data presented in Appendix B indicate that when recharge is reduced, such as during the drought year of 2002 or when the RCRA-equivalent cover is installed, pumping rates significantly lower than the design flow rate and less than the pumping rate in the model simulations will be sufficient to achieve the dewatering goals. Reductions in the capacity of a dewatering trench or well over time are common and, if occurring, may not necessarily prevent attainment of the dewatering goals. Because ROD shut-off criteria based on water quality goals do not apply to the Complex (Army) Disposal Trenches dewatering well, criteria for discontinuing dewatering operations after the dewatering goal is met will be developed during revision of the LTMP in 2007.

4.1.2.3 Groundwater Monitoring of Treatment Systems #50

The main objectives of the On-Post and Off-Post RODs that relate to groundwater monitoring are to evaluate the effectiveness of the remedies, verify the effectiveness of the on-post and off-post treatment systems, and to provide data for FYRs. The specific components of the groundwater remedies include:

On-Post

- Demonstrate that the effluent from the groundwater treatment systems for the RMA boundary systems meet CSRGs.
- Monitor to determine whether shut-off criteria are met.
- Demonstrate achievement of CSRGs for chloride and sulfate at the NBCS through natural attenuation.
- Demonstrate achievement of NDMA remediation goals at the RMA boundary.
- Evaluate the effectiveness of on-post remedies where HHE soils are left in place.

Off-Post

- Demonstrate that the effluent from the groundwater treatment systems for the off-post systems meet CSRGs.
- Monitor to determine whether shut-off criteria are met.
- Demonstrate natural attenuation of chloride and sulfate.
- Evaluate COC concentrations in groundwater within the Off-Post OU to map areas exceeding CSRGs.

The LTMP (FWENC 1999a) was designed to ensure that adequate monitoring is conducted to meet the monitoring objectives and requirements of the On-Post and Off-Post RODs.

The LTMP identified groundwater monitoring categories with specific purposes and objectives, which were later updated in the Well Retention and Closure Program (FWENC 2003a). The four monitoring categories listed below apply directly to the operation and performance of the containment and treatment systems and were used to evaluate the systems. Other monitoring categories are discussed in Section 6.4.1.

Compliance Monitoring: Effluent water quality monitoring was conducted to confirm that CSRGs were met by on-post and off-post treatment systems.

Shut-Off Monitoring: Water quality monitoring was conducted to ensure that containment systems that have met chemical concentration-based shut-off criteria defined by the RODs. Such monitoring is conducted for specified analytes for a period of 5 years to ensure that ARARs continue to be met.

Conformance Monitoring: Groundwater monitoring was conducted to determine if contaminant concentration trends conform with expectations downgradient from the boundary containment systems. Water quality data are not required to meet standards, but are evaluated against expected performance. Conformance wells were selected in the Off-Post RS/S to assess the effectiveness of the boundary containment and treatment systems in reducing downgradient contaminant levels (HLA 1996a).

Operational Monitoring: Monitoring of containment system extraction wells and monitoring wells located near the system was conducted. Data are collected from wells upgradient of and at the systems to optimize system performance and ensure that RAOs are met. Most of the wells are used for water level monitoring to ensure proper extraction system operation.

The review was conducted in accordance with the following criteria that were outlined in the LTMP:

- Compliance monitoring will be assessed based on the OARs that include four quarters of effluent monitoring for all systems for their respective CSRG lists. The FYRR will include a summary and evaluation of the effluent data extracted from the respective OARs. The purpose of the monitoring and reporting is to validate that the systems continue to meet CSRGs.
- Shut-off monitoring will be reported in terms of any changes to the program during the FYR period, potential observed trends, and future changes or additions to the program. Since such monitoring is conducted quarterly, the FYRR will present a summary of the OARs for shut-off monitoring.
- Conformance monitoring data will be collected annually, and the observed trends will be summarized in the FYRR.
- Operational monitoring is conducted through separate programs from the LTMP. However, the programs will work in conjunction with the LTMP, and monitoring results from these programs will be included by reference in the FYRR. Due to the amount of data collected under the operational monitoring programs, the FYRR will present only summary information, including contaminant trends, water level changes, and program changes that will be based on the OARs.

The results of site-wide groundwater monitoring in this FYR period are described in Section 6.4.1. The effectiveness of the site wide monitoring as it is laid out in the LTMP is addressed in Section 7.2.3.8. The monitoring results for the individual groundwater treatment systems are discussed in the following sections.

4.1.2.4 Rail Classification Yard Treatment System and Motor Pool Area Treatment System #58

The selected remedy in the On-Post ROD for the Rail Classification Yard Treatment System and Motor Pool Area Treatment System requires:

> *"Operation of existing on-post groundwater IRA systems continues. The Motor Pool and Rail Yard IRA systems, which pipe water to ICS for treatment, will be shut down when shut-off criteria...are met."*

The Irondale, Rail Yard, and Motor Pool Systems were identified in the On-Post ROD as integral to controlling the migration of contaminant plumes. The Irondale extraction system was shut off in October 1997. The CCR for the Irondale shutdown was approved by EPA on May 21, 2003 (WGI 2003b).

The Motor Pool extraction system was shut off in April 1998 and shut-off monitoring was conducted through December 2003 (PMRMA 2005b). During the shut-off monitoring period, trichloroethylene concentrations in Shutoff Monitoring Well 04535 were detected above the CSRG for two sample events in 2002. These elevated detections corresponded to a rise in the water table in the Motor Pool area. For this reason, the shut–off monitoring period for the Motor Pool was extended from April 2003 to December 2003. Approval of the CCR for the Motor Pool shutdown is anticipated during the next FYR period. Decisions with respect to future monitoring in the Motor Pool area will be discussed during revisions to the LTMP in the next FYR period.

The Rail Yard extraction system is a capture system and is still operating. The original Irondale Containment System (ICS) became operational in 1981 and was designed to remove and treat groundwater migrating toward the western boundary of RMA. The original system consisted of two parallel rows of extractions wells, one row of reinjection wells and GAC treatment. The system was updated with installation of extraction wells upgradient of the Irondale System Extraction wells were installed in the Rail Yard and Motor Pool areas as IRAs. After the Irondale and Motor Pool Systems were shut off, treatment of the remaining Rail Yard plume was moved from the ICS to the new Rail Yard Treatment System in July 2001. Recharge of the treated water was also transferred from the ICS to the Rail Yard. Two Rail Yard extraction wells, Wells 03306 and 03307, which are located downgradient of the primary Rail Yard extraction well field, were converted to recharge Wells 03401 and 03402. The objective of the original Rail Yard system, which applies to the current system, was to contain and intercept the Rail Yard plume, as specified in the Decision Document, which states, "(a) groundwater interception/containment strategy fulfills all the assessment criteria for IRAs and has been selected as the preferred strategy for the Rail Classification Yard IRA" (Shell Oil 1990).

The effectiveness of Rail Yard system is assessed in Section 7.2.1.3.

4.1.2.5 Basin A Neck Containment System #59

The selected remedy in the On-Post ROD for the BANCS requires:

> *"Operation of existing on-post groundwater IRA systems continues...The Basin F extraction system continues to extract water that is treated at the Basin A Neck system and the Basin A Neck system continues to extract and treat water from Basin A until shut-off criteria are met."*

This system treats water from the Basin A and northern South Plants areas as well as from the Bedrock Ridge intercept system and the Complex (Army) Disposal Trenches dewatering system. The BANCS also treated water from the North of Basin F extraction well until it was shut down in 2000 after the mass removal objectives had been met. CSRGs were specified in the On-Post ROD for 23 compounds for the BANCS treatment plant.

The mass removal objective of the BANCS was clarified in a September 28, 2004 Memorandum for Record. The purpose of the memorandum was "to re-state and clarify the requirements for the BANCS in the Record of Decision for the On-Post Operable Unit" (RVO 2004b). A reverse hydraulic gradient is maintained in the middle of the system, but the recharge trenches do not extend to the ends of the slurry wall where a reverse gradient is not achieved. Concentrations of most contaminants in the downgradient monitoring well were below CSRGs or showed decreasing trends. As with the other systems, operational changes have been implemented to ensure protectiveness is maintained. Due to biological fouling of the BANCS recharge trenches by manganese bacteria, two new trenches were constructed in 2004 (WGI 2003a, WGI 2004). The air stripper was replaced in 2004 and now treats all the flow through the treatment plant instead of just a sidestream (formerly from the North of Basin F Extraction Well). The new air stripper provided an added benefit in that it reduced the biofouling of the recharge trenches and some of the capacity in the trenches was regained.

The performance of the BANCS during the FYR period is evaluated in Section 7.2.1.4.

4.1.2.6 North of Basin F Groundwater Plume Remediation System #59

The selected remedy in the On-Post ROD for the North of Basin F Groundwater Plume Remediation System requires:

> *"Operation of existing on-post groundwater IRA systems continues... The Basin F extraction system continues to extract water that is treated at the Basin A Neck system and the Basin A Neck system continues to extract and treat water from Basin A until shut-off criteria are met."*

The system was constructed upgradient of the North Boundary Containment System (NBCS) to reduce the contaminant load on the system and accelerate cleanup of contaminated groundwater associated with Basin F. The system began operations on October 1, 1990 and was shut off permanently on September 22, 2000.

The mass removal data for the North of Basin F Extraction Well indicates that the ROD objectives have been met and support closing out this part of the groundwater remedy. The system was highly effective in removing mass, but the contaminant mass removed decreased from 123 pounds in 1996 (October 1, 1995 through September 30, 1996) to 3.95 pounds in 2000 (October 1, 1999 through September 22, 2000). Flows from the extraction well decreased from 1.6 gpm in 1996 to 0.5 gpm in 2000. The decrease in mass removal is due to significantly lower contaminant concentrations and decreased flow in the well due to a lower water table. Based on this decrease in mass removal and the decrease in flow in the well, it was determined that continued operation of the well would result in "diminishing returns."

The RMA Committee agreed that the IRA had been completed and that a CCR should be issued. The CCR was prepared for the North of Basin F Groundwater Plume Remediation System (WGI 2005). The CCR covers the period from the signing of the ROD in June 1996 to shutoff of the system in September 2000. The CCR was approved by EPA on September 28, 2005. In addition, the IRA Summary Report for the system (EPA 2000a) covers the period from the startup of the system through the signing of the On-Post ROD on June 11, 1996.

4.1.2.7 Northwest Boundary Containment System #61

The selected remedy in the On-Post ROD for the NWBCS requires:

> *"Operation of the three boundary systems, the NBCS, NWBCS, and ICS, continues. These systems include extraction and recharge systems, slurry walls (NBCS and NWBCS) for hydraulic controls, and carbon adsorption for removal of organics. The systems will be operated until shut-off criteria ...are met."*

The performance objective for the Northwest Boundary Containment System (NWBCS) is defined as follows:

> *"Prevent off-post migration of contaminated groundwater through containment and capture of contaminated water migrating toward the Northwest Boundary".*

The NWBCS is a containment system designed to prevent the off-post migration of contaminated groundwater (RMA 1981). The NWBCS consists of the following three components:

- NWBCS Original System: The original extraction well system and 1425 ft of slurry wall installed in 1984.
- NWBCS Northeast Extension: The extraction wells and 665 ft of slurry wall installed as part of the Short-term Improvements IRA at the Northeast end of the system (MKE 1990).
- NWBCS Southwest Extension: The extraction and recharge systems installed as part of the Short-Term Improvements IRA in 1991 to address dieldrin contamination southwest of the original containment system. No slurry wall is present in this area.
- Extracted water is treated with GAC adsorption
- Treated water is reinjected into recharge trenches.

The On-Post ROD established CSRGs for the NWBCS effluent for eight contaminants potentially present in the groundwater migrating toward the northwest boundary.

The performance of the NWBCS is evaluated in Section 7.2.1.5.

4.1.2.8 North Boundary Containment System #62

The selected remedy in the On-Post ROD for the NBCS requires:

> *"Operation of the three boundary systems, the NBCS, NWBCS, and ICS, continues. These systems include extraction and recharge systems, slurry walls (NBCS and NWBCS) for hydraulic controls, and carbon adsorption for removal of organics. The systems will be operated until shut-off criteria ...are met.*
>
> *Chloride and sulfate are expected to attenuate naturally to CSRGs."*

The performance objective for the NBCS is defined as follows:

> *"Prevent off-post migration of contaminated groundwater through containment and capture of contaminated water migrating toward the North Boundary".*

The NBCS is a containment system designed to prevent the off-post migration of contaminated groundwater (USACE 1985). To treat the plumes migrating toward the north boundary, the current NBCS consists of (1) a system of extraction wells that remove contaminated groundwater from the unconfined flow system (UFS), (2) a soil bentonite barrier that impedes migration of contaminated groundwater to the Off-Post OU, (3) a carbon-adsorption treatment system that removes organic contaminants from extracted groundwater, (4) an ultraviolet (UV)-oxidation system for treatment of NDMA, and (5) a system of recharge trenches that return treated groundwater to the UFS north of the slurry wall. A reverse gradient across the barrier is maintained to prevent contaminated groundwater from moving off post.

The containment system originally consisted of a slurry wall with extraction wells upgradient and injection wells downgradient of the slurry wall. This system was originally installed as a pilot project in 1979 and extended to its current extent in 1981. The system was unable to maintain a reverse hydraulic gradient and, consequently, it was modified by replacing the injection (recharge) wells with 15 recharge trenches. As a result of the changes, a reverse hydraulic gradient has been maintained across the entire alluvial part of the system and most of the Denver system since 1992. A carbon adsorption system has been used to remove organic compounds from the influent prior to recharge. An ultraviolet-oxidation treatment system installed at the NBCS has been treating NDMA since September 1997.

During the FYR period, two different actions were proposed to enhance the effectiveness of the NBCS. The actions, listed below, are documented in the NBCS Fact Sheet (RVO 2004c):

- Adding two groundwater extraction wells upstream of the existing NBCS well field.
- Injecting hydrogen release compound into the groundwater aquifer farther upstream from the existing NBCS extraction wells to enhance biodegradation of organic contaminants.

The purpose of the additional extraction wells, which were installed in 2003, was to accelerate groundwater cleanup. The upgradient wells will also help maintain a reverse hydraulic gradient at the NBCS.

The injection of biodegradation-enhancing hydrogen release compound is an innovative technology that was tested in pilot studies conducted at RMA through the EPA SITE program (TTEMI 2003). The location, approach, and design of the in situ treatment system were developed during the FYR period and the injection of biodegradation-enhancing compounds started in May 2005. For that reason, the results will be evaluated as part of the next FYR.

CSRGs for the NBCS effluent were established for 29 contaminants potentially present in the groundwater migrating toward the north boundary. Of these compounds, chloride and sulfate levels were to be reduced to CSRGs through natural attenuation over time periods of 30 and 25 years respectively. The RMA On-Post OU identified natural attenuation as a remedy for chloride and sulfate at NBCS, and a study of regional concentrations and flow rates upgradient of the NBCS was conducted to evaluate remediation goals as well as remediation timeframes for these compounds (MKE 1996). Based on this study, the CSRG for chloride was set at the CBSG of 250 milligrams per liter (mg/l), and the timeframe for achieving the CSRG in the NBCS effluent was predicted to be 30 years. For sulfate the CSRG was set at 540 mg/l based on regionally high levels of sulfate in groundwater, and the timeframe for achieving this was predicted to be 25 years.

The performance of the NBCS during the FYR period is evaluated in Section 7.2.1.6.

4.1.2.9 South Lakes Plume Management #64

The selected remedy in the On-Post ROD requires:

> *"Lake-level maintenance or other means of hydraulic containment or plume control will be used to prevent South Plants plumes from migrating into the lakes at concentrations exceeding CBSGs in groundwater at the point of discharge. Groundwater monitoring will be used to demonstrate compliance."*

During the FYR period an evaluation of contaminant migration was conducted in accordance with the *Rocky Mountain Arsenal South Lakes Sampling and Analysis Plan for Groundwater* (USGS 2001a). This monitoring program, which focused on monitoring contaminant migration into Lake Ladora, revised a previous evaluation project (FWENC 1997).

The data quality objectives for the monitoring program were developed to answer the following questions:

- Do conditions allow potential migration into the South Lakes?
- Do contaminants migrate into the South Lakes at groundwater concentrations exceeding the CBSGs at the point of discharge?

Groundwater monitoring results showed that the contaminants from the South Plants plume were not detected in the point of compliance (i.e. point of discharge) wells or in Lake Ladora at concentrations exceeding the CBSGs. Since a reverse hydraulic gradient was not maintained during a significant portion of the monitoring period, the results showed that contaminants did not migrate into Lake Ladora even under the most unfavorable flow conditions, i.e., conditions that allowed migration into the lake. These data confirm that South Plants plumes are not migrating into the lakes at concentrations exceeding CBSGs in groundwater (USGS 2004a). Based on the results of the South Lakes groundwater monitoring study, the decision was made to proceed with an ESD to remove the lake level maintenance required by the ROD for plume management. The ESD was approved by EPA on March 31, 2006 (TTECI 2006a).

4.1.3 Completed On-Post Groundwater Remedies

4.1.3.1 Confined Flow System Well Closures #57

The selected remedy in the On-Post ROD for the Confined Flow System Well Closures requires:

> *"Those monitoring wells installed in the confined aquifer that may represent pathways for migration from the unconfined aquifer (approximately 30–40 wells) are closed and sealed; replacement wells will be installed if the Parties jointly determine that specific wells to be closed are necessary for future monitoring."*

Between 1993 and 1995, available data for approximately 3,000 wells were evaluated. Data evaluated included groundwater chemical data, well completion data, and lithologic data. In addition, the hydrographs of the UFS wells were compared with nearby Confined Flow System (CFS) wells. Of the more than 800 wells identified as completed in the CFS, 51 wells were identified as potential conduits from the UFS to the CFS because of poor or suspected poor well construction, or because the hydrographs and potentiometric elevations of the UFS and nearby CFS wells were similar. Wells were also identified as potential conduits if insufficient documentation was available regarding well construction, including presence of grout and location of bentonite seals and screens.

For these 51 wells, the well casings were overdrilled and a grout plug was installed in the borehole. This closure technique reflected a conservative approach intended to provide the highest level of mitigation of potential groundwater migration between the UFS and CFS. In addition, the closure technique meets the Colorado requirements for Water Well Construction Rules, 2 Code of Colorado Regulations 402-2, Rule 15, Standards for Plugging, Sealing and Abandoning Wells and Boreholes.

In addition to the 51 wells closed under this project, CFS well 36182 was identified by CDPHE as a highly contaminated well requiring closure. The well was closed in May 2000 and its closure enhanced the protectiveness of the remedy (Maxim 2000).

As documented in the CCR (D&M 2000), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by RVO and the Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on September 27, 2000.

4.1.3.2 Irondale Containment System Main Wellfield Treatment (shutdown) #58

The selected remedy in the On-Post ROD for the ICS requires:

> *"Operation of the three boundary systems, the NBCS, NWBCS, and ICS, continues. These systems include extraction and recharge systems ... and carbon adsorption for removal or organics. The systems will be operated until shut-off criteria ...are met.*
>
> *Shell and the Army will operate the ICS for 2 years or until the Rail Yard/Motor Pool plumes no longer require containment at the ICS."*

The ICS was one of the early remediation actions completed on the RMA as part of the On-Post OU. The system was constructed to address groundwater contamination issues in the Irondale Gulch. The original system, constructed in 1981, included the ICS treatment plant and the Irondale Extraction System. Subsequent to the original construction, it was determined that contaminated water in the Irondale Gulch plume could be extracted more efficiently by installing additional extraction wells upstream of the original system. Further upstream of the ICS the Motor Pool and Rail Yard Extraction Systems were installed as IRAs. Once it was apparent that the Irondale and Motor Pool Extraction Systems met shutdown criteria, it was determined that improvements in system efficiency could be accomplished by installing a smaller, more efficient, treatment system closer to the remaining plume in the Rail Yard area. The Irondale Extraction System (main wellfield), Motor Pool Extraction System, and Rail Yard Extraction System are components of the ICS. The collective purpose of the three components was to treat the groundwater plume in the Irondale Gulch.

The main wellfield of the Irondale Extraction System is located at the southwest corner of Section 28 and the northwest corner of Section 33. Shell built the system to treat and eliminate the off-post migration of the groundwater containing dibromochloropropane (DBCP). The ICS became operational in December 1981. The Irondale Extraction System, as part of the ICS, met the shutoff criteria in the ROD and was shut off on October 1, 1997.

After the Irondale Extraction System was shut-off, the ICS plant continued to treat groundwater from the Rail Classification Yard and Motor Pool Extraction Systems. The treated groundwater continued to be reinjected into the aquifer in the ICS recharge wells. The Motor Pool Extraction System was shut down on April 1, 1998. The ICS plant was shut down on July 23, 2001. The treatment of groundwater from the Rail Yard Extraction System was transferred from the ICS plant to the Rail Yard Treatment System which began operations on July 26, 2001, and recharge of treated groundwater was also transferred from the ICS wells to Rail Yard wells. The ICS plant was then demolished as part of the Miscellaneous RMA Structure Demolition and Removal Project - Phase I. For additional information see Section 4.4.2.3.

As documented in the CCR (WGI 2003b), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on May 21, 2003.

4.2 Off-Post OU Groundwater Remedy Selection and Implementation

The Off-Post ROD (HLA 1995) identified the following remedial components for off-post groundwater:

- *Operation (and improvement if necessary) of the OGITS*
- *Continued operation (and improvement, if necessary) of the NBCS and NWBCS*
- *Long term groundwater and surface water monitoring*
- *Provision of alternative water supplies and implementation of institutional controls intended to prevent future use of contaminated groundwater.*

The selected remedy for each component is discussed below.

4.2.1 Operating Off-Post Groundwater Remedies

The operation of the OGITS is addressed in detail in the OARs (PMRMA 2005a, 2005b, 2005c, 2003a, 2002b). O&M costs have been included in the OARs since 2002.

The costs presented in the OARs are based upon all field costs including utilities and analytical support. The treatment plant O&M costs over this FYR review period have fluctuated within expected limits; there are no obvious upward or downward cost trends. The largest normal fluctuation in costs from year to year is based on changes in lab and sampling costs. As discussed in the annual OAR, there were maintenance actions at the OGITS that caused short duration cost increases. In 2003 the double containment piping in the First Creek well field failed. Investigation into the piping system indicated that this type of failure was common and had been identified by the manufacturer of the piping. The double containment product line was subsequently discontinued. The piping was replaced with a more reliable HDPE material.

4.2.1.1 Off-Post Groundwater Intercept and Treatment System #94

The selected remedy in the Off-Post ROD for the OGITS requires:

> *"Removal of contaminated UFS (Unconfined Flow System) groundwater north of the RMA boundary in the First Creek and northern paleochannels, using Offpost Groundwater Intercept and Treatment System groundwater extraction wells.*
>
> *Treatment of the extracted groundwater, using carbon adsorption.*
>
> *The Army will treat any contaminated groundwater prior to discharge or reinjection so that it meets the current water quality standards established in the Colorado Basic Standards for Groundwater and the Colorado Basic Standards and Methodologies for Surface Water.*
>
> *Recharge of treated groundwater to the UFS, using Offpost Groundwater Intercept and Treatment System recharge wells and trenches."*

The OGITS was designed as a mass removal system (HLA 1989) and has operated as such since startup in 1993. The mass removal objectives identified in the Interim Response Action Design Document (HLA 1989) for the OGITS are as follows:

- Mitigate migration of contaminants in alluvial groundwater as soon as practicable.
- Treat contaminated alluvial groundwater to provide a beneficial impact on groundwater quality.

The words "contain" and "containment" have often been used to describe the OGITS, including in the Off-Post ROD. However, containment is not compatible with system design and the system will continue to operate as a mass removal system. The major remedy components identified for operation of the OGITS in the ROD are:

- Removal of contaminated groundwater from the alluvial and the weathered upper portion of the Denver Formation (hereafter called the UFS) north of the RMA Boundary in the First Creek and Northern paleochannels using groundwater extraction wells.
- Treatment of the organic COCs present in the groundwater using carbon adsorption
- Recharge of treated groundwater to the UFS using wells and trenches.

The OGITS includes two extraction and recharge systems located in the First Creek and northern pathways. The OGITS is an array of extraction wells, recharge trenches, and recharge wells in the Northern and First Creek paleochannels. The northern paleochannel collection system consists of 12 extraction wells and 24 recharge wells. The First Creek paleochannel collection system consists of five extraction wells and six recharge trenches. Water is treated by granulated activated carbon adsorption before reinjection. System performance information is presented in the OARs for the FYR period (PMRMA 2005a, 2005b, 2005c, 2003a, 2002b). CSRGs for the OGITS effluent were established for 34 contaminants potentially present in the Off-Post OU.

The effectiveness of the OGITS systems is evaluated in Section 7.2.2.1.

The property on which the NPS is located has been acquired by Amber Homes, Inc. whose plans for the property include the development of a large retail center and residential areas that entail construction at the NPS location. Based on discussions between Amber Homes, the Army, and the Regulatory Agencies, agreement was reached on relocating the NPS to the southeastern perimeter of the Amber Homes property.

The modifications to the NPS affect the extraction system and the associated recharge wells used for reinjection of treated groundwater, as described in the Conceptual Design Document (Amber Homes, Inc, 2005). The modified system has been designed to meet or exceed the contaminant removal efficiency of the original system The original NPS and the modified system will be operated and monitored concurrently until the original NPS wells meet shut-off criteria and extraction is discontinued.

Four of the original NPS extraction wells, Wells NE7, NE 8, NE 9, and NE 10 (37811 through 37814), were shut off for hydraulic reasons in 2004 and three of these wells were abandoned to make room for the re-alignment of Peoria Street as part of the Amber Homes development. Two of the original First Creeks extraction wells, Well FE4 and Well FE5 (Well 37803 and Well

37804) were shut off for hydraulic reasons in 2003. Appropriate ROD change documentation of the relocation of the NPS will be prepared.

4.2.1.2 Private Well Network #96

The Private Well Network program is administered by TCHD via a Memorandum of Agreement with the Army (PMRMA 1997a). Under this program, TCHD samples private wells and surface water sources in the off-post study area. Each year, sample locations are selected based on the criteria listed in the LTMP. The objectives of this sampling effort are to:

- Provide data to assist in refining the CSRG exceedance area
- Sample new wells installed in the off-post area as required by the Off-Post ROD
- Sample existing wells in response to citizen requests
- Sample CFS wells that may act as conduits for contaminants to migrate from the shallower UFS to the CFS.

In addition, TCHD samples surface water discharges from gravel operations, and maintains a database with demographic information regarding private wells in the CSRG exceedance area.

Annually TCHD prepares and provides a candidate sampling list for RVO, EPA, and the Colorado Department of Public Health and the Environment (CDPHE) review. After receiving and incorporating comments, the candidate sampling list is finalized. Sampling of approximately 50 wells takes place each summer. Private well samples are taken with the permission of the well owner. TCHD samples the wells on the candidate sampling list and the private wells recommended for sampling in the first FYR unless:

- The well has been taken out of service as a result of connection to a public water supply or development in the area where the well is located.
- TCHD is unable to make contact with the well owner to obtain permission to sample.
- The property owner denies access.

As new demographic information and the water quality data become available in the area of interest, it is entered into TCHD and RVO Environmental Databases. Approximately 250 wells and surface water sources have been sampled under this program since the last FYR. The results of the program are provided annually by TCHD to the RVO, EPA, and CDPHE.

4.2.1.3 Off-Post Institutional Controls #98

The Off-Post ROD includes the use of an institutional control with the objective of:

> "Pr*evention of the use of the groundwater underlying areas of the Off-Post OU exceeding groundwater containment system remediation goals."*

The RS/S for the Off-Post OU provides further specifics on the implementation of institutional controls (HLA 1996a). The primary mechanism for implementing the institutional controls is a well notification program developed in conjunction with the SEO, TCHD and the Army. Under this program, the Army provides the SEO with a map identifying notification areas in the Off-Post Study Area. To be conservative, the notification area is much larger than the area where groundwater actually exceeds CSRGs. The SEO uses the updated notification map to notify well applicants that their wells are in the RMA area where contaminated groundwater may be encountered. The Army also provides the SEO updated groundwater exceedance maps for information purposes. As it processes well permit applications, and/or drilling permits within the area delineated on the notification map, the SEO is asked to place a notification statement on the well permit applications.

The CSRG exceedance map updates follow the twice-in-five year groundwater exceedance monitoring conducted in the Off-Post area. Similarly the notification maps are modified jointly by Army and TCHD based upon the updated CSRG groundwater exceedance maps.

The past FYR concluded that the well notification process had not been completely effective, e.g., notifications were not included on all well permits issued in the notification area. To improve the process, the past FYR included the recommendations discussed in Section 5.2.2.

As part of the 2005 FYR, TCHD performed a review of permits issued in the notification area to evaluate whether the past FYR recommendations were performing as intended (TCHD 2005). TCHD found:

- Over 90 permits had been issued in the notification area since the first RMA FYR. Most of the permits were for monitoring wells. Two were private Arapahoe wells that were sampled later by TCHD and found to have no diisopropylmethylphosphonate (DIMP) exceedances.
- The notification agreed to by the Army and the SEO was only found on three denied applications and on four well permits.
- The SEO does not appear to be following a standard procedure for transmitting copies of all well permits to the Army, EPA, and TCHD.

Discussions with representatives of the SEO led TCHD to believe that the difficulties with the notification process are the result of staff turnover in the SEO. The SEO indicated a willingness to modify internal procedures to assure that the well permit notification program is appropriately implemented.

Despite the absence of notification, no new drinking water wells that were installed during the FYR period were contaminated. See Section 7.2.2.3 for the assessment of this task.

4.3 On-Post Soil Remedy Selection and Implementation

The On-Post ROD specified the following RAOs for the On-Post soil remedy:

<u>Human Health</u>

> *"Prevent ingestion of, inhalation of, or dermal contact with soil or sediments containing COCs at concentrations that generate risks in excess of 1 x 10^{-4} (carcinogenic) or an HI greater than 1.0 (noncarcinogenic) based on the lowest calculated reasonable maximum exposure (5th percentile) PPLV values (which generally represent the on-site biological worker population).*
>
> *Prevent inhalation of COC vapors emanating from soil or sediments in excess of acceptable levels, as established in the HHRC.*

Prevent migration of COCs from soil or sediment that may result in off-post groundwater, surface water, or windblown particulate contamination in excess of off-post remediation goals.

Prevent contact with physical hazards such as UXO.

Prevent ingestion of, inhalation of, or dermal contact with acute chemical agent hazards."

Ecological Protection

"Ensure that biota are not exposed to COCs in surface water, due to migration from soil or sediment, at concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.

Ensure that biota are not exposed to COCs in soil and sediments at toxic concentrations via direct exposure or bioaccumulation."

The selected remedy, ROD standards and ROD goals are presented below in the context of the implementation projects.

4.3.1 On-Post Soil Remedies Under Construction

4.3.1.1 Construct the Enhanced Hazardous Waste Landfill #11

The selected remedy in the On-Post ROD for construction of the ELF requires:

"Construction of a RCRA- and TSCA-compliant hazardous waste landfill on post. Basin F Wastepile ...containment in dedicated triple-lined landfill cells."

The ROD remediation standards that apply to the landfill and liner element of the project include:

"Landfill principal threat and human health soil exceedance volumes and agent-contaminated material.

Design landfill to meet state 1,000-year siting criteria.

Ensure all material disposed in landfill passes EPA paint filter test.

Minimize percolation by limiting the hydraulic conductivity of the clay layer to $1x10^{-7}$ *cm/sec or less.*

Install two composite liners, each consisting of 3 ft of compacted clay and a synthetic liner, and one additional composite liner.

Meet or exceed all RCRA and state requirements.

Meet air quality and odor standards that are ARARs."

The ROD goals that apply to the project include the following:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

The design for the ELF was completed in 2002 and met all requirements in the ROD, the Corrective Action Management Unit (CAMU) Designation Document (HLA 1996b) and the Certificate of Designation (Adams County 1997). The landfill is triple-lined and has 1.1 million cubic yards (cy) of airspace. ELF site preparation activities began during August 2003 with removal of vegetation in the site area and construction of the perimeter fence. Excavation and berm construction began during October 2003 and was completed in May 2004. The ELF liner system was constructed in two construction seasons. Construction of the Part 1 liner system began in May 2004. Work on the Part 2 liner system began in April 2005 and was completed in late October 2005.

Miscellaneous infrastructure construction began in September 2004 and was completed during June 2005. Major components include: the leachate riser control houses, the leachate storage/loadout facility, the contingent contaminated stormwater control system, the leachate transfer piping from cells, the contaminated storm water piping, the potentially contaminated stormwater piping and the potable water piping. All underground piping components are dual-walled with the exception of the potable water piping. The ELF was prepared to accept waste in 2006.

As discussed in Section 6.3.5, prior to construction of the ELF, an evaluation was performed in an attempt to explain the presence of DIMP in leak detection water of Cell 2 of the HWL. The evaluation was performed not only to understand the source of the DIMP but also to prevent a similar result at the ELF. Ultimately, the sanitary sewer line that traversed Borrow Area 5 was the most likely source of contaminated clay used in the HWL Cell 2 liner system. As a result, no clay within 50 ft. of the original sanitary sewer alignment and no clay from locations less than 10 ft. from the historic high water table were used to construct the ELF liner system.

The ROD included excavation of waste from the Basin F Wastepile and the Section 36 Lime Basins with disposal in the ELF. During the FYR period, a remedy change was proposed that eliminated excavation and landfill of the Lime Basins waste but added excavation and disposal in the ELF for Basin F principal threat soil. This proposed change in remedy along with other considerations resulted in concerns regarding adequacy of landfill capacity for remaining remediation wastes. In response to these concerns, a Summary of Alternatives was developed (TTFWI 2005a), culminating in a ROD Amendment (TTECI 2005a), that included an assessment of ELF capacity to ensure that the selected remedy could be implemented with the current ELF design capacity. As a result, sufficient ELF capacity remains available and remaining capacity is carefully monitored. See Section 6.3.11 for additional discussion. The assessment of this project is presented in Section 7.1.1.

4.3.1.2 Existing (Sanitary) Landfills Remediation Section 30 #22

The selected remedy in the On-Post ROD for the Sanitary Landfills component of the soil remedy requires:

> "*Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of landfill debris and soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*"

The selected remedy in the On-Post ROD for revegetation is:

"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."

The ROD remediation standards that apply to the sanitary landfills include:

"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.

Meet air quality and odor standards that are ARARs."

The ROD goals that apply to the project include the following:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

The Existing (Sanitary) Landfills (ESL) Section 30 Remediation Project consisted of Site ESA-2b, located in Section 30. The project involved excavation and removal of both HHE soil and trash/debris; excavation and removal of asbestos-containing material (ACM) and associated soil; excavation and removal of suspect hazardous materials; backfilling, compacting, final grading and ripping; perimeter fence removal and staging for reuse; soil amendment application, and surface revegetation. All HHE Soil, ACM, and suspect hazardous materials were transported to the on-site HWL for disposal. All trash and debris were disposed Basin A.

Although not anticipated in the ROD, further evaluation during design indicated the possibility of munitions and explosives of concern (MEC). As a result, spotters were present during excavation and several munitions-related anomalies were addressed. Items that contained liquids (i.e., bottles) were taken to the Environmental Analytical Laboratory and analyzed; none contained agent. Solid anomalies were cleared following further characterization. Energetic items were determined unstable and detonated in place or at the on-site demolition range.

Disposal of trash and debris, munitions debris and associated soil, and HHE soils, ACM and associated soil was documented using a waste tracking system as specified in the Remediation Waste Management Plan (RWMP)(TTECI 2006b). A total of 874 cy of HHE soil and 115 loads of ACM were disposed in the HWL during the course of the project. Approximately 143,515 cy were disposed Basin A. Final waste volumes are not available and will be presented in the third FYRR.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the ESL Project, one confirmatory sample was taken. No Contingent Soil Volume (CSV) was excavated. All soils removed were verified by pre- and post-excavation surveys.

All trenches were backfilled. After the remedial excavation and backfilling was completed and survey documentation and inspections approved by the RMA Program Management Contractor (PMC), RVO and Regulatory Agencies, the site was finish-graded to promote positive drainage and to blend into the surrounding grades.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring personal protective equipment (PPE) upgrade during the project.

In May 2005, an ESD entitled "Explanation of Significant Differences for Existing (Sanitary) Landfills Soil Remediation Project" was approved (TTECI 2005b). The ESD documents an increase in HHE and biota soil excavation volumes associated with the landfill sites due to over excavation of required volume to ensure complete removal. The ESD also documents a significant decrease in trash/debris volume. Trash/debris volume was identified in the ROD based on estimated trench depth and lateral extent. Remediation was performed to excavate all visible trash/debris from each identified trench. The reduced volume is based on the differences between ROD-assumed landfill trench depths and lateral extents and actual debris encountered during excavation.

The ESL Section 30 project requires no caps, covers or treatment facilities, therefore no long-term O&M is required. A CCR was approved by EPA on August 16, 2005 (TTECI 2005c). As documented in the CCR, remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs.

4.3.1.3 Munitions (Testing) Soil Remediation Part II #25

The selected remedy in the On-Post ROD for the Munitions Testing component of the soil remedy requires:

> "*UXO in these sites is located using a geophysical survey, excavated, and transported offpost for detonation (unless the UXO is unstable and must be detonated on-post) or other demilitarization process. Removal and landfill of munitions debris and nearby soil in excess of TCLP.*"

The selected remedy in the On-Post ROD for revegetation is:

> "*Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*"

The ROD remediation standards that apply to the Munitions Testing remediation project include the following:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
>
> *Ensure excavation of all identified munitions-contaminated soil exceeding TCLP (Munitions Testing and Burial Trenches) and munitions debris and disposal in the on-post RCRA landfill.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD goals that apply to the project include the following:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

Soil sampling in support of design demonstrated that soil associated with munition debris areas passed the Toxicity Characteristic Leaching Procedure (TCLP) criteria. As a result Munitions Testing Part II only involves anomaly characterization in Site ESA-4a, Site BT32-10 and Borrow Area 10.

Although Site ESA-4a was originally considered complete, based on historical research performed by the Evaluation Team (Evaluation Team 2002) regarding the flight path of the 4.2 inch High Explosive mortar on RMA, the original ROD surface area of Munitions Testing Site ESA-4a was expanded. During the RI, an evaluation of Site 30-1 noted the location of impact craters and a concrete bunker used to observe mortar impacts (ESE 1988a, 1988b). The concrete bunker had observation windows facing northwest and northeast suggesting that the main impact range was north of the bunker. A 42-acre parallelogram was used to bound the mortar impact area and the site was designated ESA-4a. As part of the remedial design, in 1998 a magnetic survey was performed by Sanford Cohen & Associates (SC&A 1998) to identify locations of potential subsurface MEC. This led to the characterization of 326 targets, four of which were characterized as MEC.

As noted above, in late 2001 the Evaluation Team discovered a draftsman's sketch (circa 1945) indicating the mortar impact area may have extended beyond the previously investigated ROD site limits. In January of 2002 the Evaluation Team recommended expanding the remediation area. Site ESA-4a was subsequently expanded (parallelogram was extended 3.3 acres to the southeast and 7 acres to the west). The PMC was tasked to clear an additional 35 targets from the 1998 SC&A survey area. While characterizing the previously mentioned targets, the PMC discovered 14 additional targets within the original ROD boundary that had not been investigated. One of these 14 targets resulted in the clearance of three 4.2 inch High Explosive mortars which were subsequently characterized as MEC. Due to concerns that additional MEC may exist in areas outside the 42-acre ROD site and the additional 10.3 acres, the boundary of ESA-4a was expanded to include most of Site 30-1 (approximately 212 acres).

As a result of the RMA Council resolution (RMA Council 2004a) and subsequent amendment (RMA Council 2004b), anomalies detected during either geophysical survey that were subsequently considered targets were to be characterized upon Munitions Testing Site ESA-4a project completion.

Two CCRs were to be completed for the Munitions Testing project documenting that the subject work has been completed in accordance with the ROD. The first CCR (Part I), already completed, addressed the work scope completed from March through November of 2000 and is discussed in Section 4.3.3.10. The second CCR (Part II) will address the additional work scope assigned to the project (e.g., characterization and remediation work at Munitions Testing project Sites ESA-4a and BT32-10) as a result of the Evaluation Team efforts during the Spring/Summer of 2002. In addition, an ESD will be prepared to document a decrease in remediation volumes based upon a comparison of ROD estimated volumes to actual volumes excavated.

4.3.1.4 South Plants Balance of Areas and Central Process Area Soil Remediation Phase 2 Part 1 and 2 #34

The selected remedy in the On-Post ROD for the South Plants Central Processing Area component of the soil remedy requires:

> *"Excavation and landfill of principal threat and human health exceedance exceedance soil to a depth of 5 ft and caustic washing and landfill of any agent-contaminated soil found during monitoring. Backfill excavation and placement of a soil cover consisting of a 1-ft-thick biota barrier and a 4-ft-thick soil/vegetation layer over the entire site to contain the remaining human health exceedance soil and soil posing a potential risk to biota. Soil posing a potential risk to biota from other portions of South Plants may be used as backfill and/or gradefill prior to placement of the soil cover."*

The selected remedy in the On-Post ROD for the South Plant Balance of Areas component of the soil remedy requires:

> *"Excavation (maximum depth of 10 ft) and landfill of principal threat and human health exceedance soil and caustic washing and landfill of any agent-contaminated soil found during monitoring. Any UXO encountered will be excavated and transported off-post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Excavation of soil posing a potential risk to biota and consolidation as backfill and/or gradefill under the South Plants Central Processing Area soil cover and/or for use as backfill for excavated areas within this medium group. The former human health exceedance area is covered with a 3-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover. Prior to placing this cover, two composite samples per acre will be collected to verify that the soil under the 1-ft.-thicK cover does not exceed the human health or principal threat criteria. If the residual soil is found to exceed these levels, the 3-ft-thick cover will be extended over these areas or the exceedance soil will be excavated and landfilled. The top 1 ft of the entire soil cover area will be constructed using soil from on-post borrow areas."*

The selected remedy in the ROD for the South Plant Ditches component of the soil remedy requires:

"Excavation and landfill of principal threat and human health exceedance soil. Excavation of soil posing a potential risk to biota and consolidation under the South Plants Central Processing Area soil cover. Backfill excavated area with on-post borrow material. These sites are contained under the South Plants Balance of Areas soil cover."

The selected remedy in the On-Post ROD for the Chemical Sewers component of the soil remedy requires:

"For sewers located within the South Plants Central Procession Area...the sewer void space is plugged with a concrete mixture to prohibit access to these lines and eliminate them as a potential migration pathway for contaminated groundwater. The plugged sewers are contained beneath the soil cover or cap in their respective sites. For sewers located outside the South Plants Central Procession Area...sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced."

The selected remedy in the On-Post ROD for the Sanitary/Process Water Sewers component of the soil remedy requires:

"Void space inside sewer manholes is plugged with a concrete mixture to prohibit access and eliminate the manholes as a potential migration pathway for contaminated groundwater. Aboveground warning signs are posted every 1,000 ft. along the sewer lines to indicate their location underground."

The selected remedy in the On-Post ROD for polychlorinated biphenyl (PCB) -contaminated soil requires:

"Soil identified with concentrations ranging from 50 to 250 ppm will be covered with at least3 ft of soil (five areas identified by the PCB IRA)."

In addition, the selected remedy in the On-Post ROD for structures located in South Plants requires:

"The slabs and foundations of structures located in the South Plants Central Processing Area within principal threat or human health soil exceedance excavation areas are removed to a depth of 5 ft. In most cases, floor slabs and foundations of structures for the Other Contamination History and Significant Contamination History Groups are left behind after demolition (unless contaminated soil is to be excavated from beneath the slabs or foundations). Floor slabs are broken to prevent water ponding."

The selected remedy for revegetation is:

"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."

The ROD remediation standards that apply to the project include:

"Identify, transport off-post, neutralize, and destroy explosives/explosive residue.

Ensure excavation of all identified munitions-contaminated soil exceeding TCLP (Munitions Testing and Burial Trenches) and munitions debris and disposal in the on-post RCRA landfill.

Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.

Interrupt exposure pathway with a minimum of 3 ft of soil in the five areas identified as having PCB contamination <250 ppm.

Interrupt exposure pathway by permanently plugging all Sanitary Sewer manholes.

Interrupt exposure pathway by permanently plugging all chemical sewer lines and manholes not excavated.

Certify 3X decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.

Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.

Meet air quality and odor standards that are ARARs."

The ROD goals that apply to the project include:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

The South Plants Balance of Areas and Central Processing Area Soil Remediation Project was separated into two phases (Phase 1 and Phase 2) during the 95 percent design development. Phase 1 included excavation of contaminated soil and chemical sewers, ACM abatement, underground storage tank removal, foundation removal, backfilling/grading and placement of interim revegetation and is discussed in Section 4.3.3.18.

An ESD (FWENC 2000a) was prepared during South Plants Balance of Areas and Central Processing Area Soils Phase 1 project, and is applicable to both Phase 1 and Phase 2. The ESD was approved by the Regulatory Agencies on November 10, 2000, following completion of the public review and comment period, from which no comments were received. The ESD documents and provides rationale for changes to the ROD-identified remedy for this project.

The changes to the South Plants remedy documented in the ESD are as follows:

- Removal of the requirement for a 1-ft. cover in the South Plants Balance of Areas and replace with 1 ft. of backfill
- Enhancement of construction standards for the South Plants Central Processing Area cover
- Removal of the requirement to excavate Biota soil from under the South Plants Balance of Areas 3-foot cover area

As described in the ESD, an enhanced sampling program was conducted that included collection of 200 samples in addition to the ROD-required 2 samples per acre for a total of more than 600 samples over 208 acres. The ESD also required removal of all identified HHE soil and removal of all Biota soil in the 1-ft. backfill area.

As noted above, the South Plants Balance of Areas and South Plants Central Processing Area Soil Remediation Project was separated into two phases (Phase 1 and Phase 2) during the design development. This section discusses Part 1 and Part 2 of Phase 2.

Phase 2, Part 1 included remediation of HHE and biota soil as part of cover subgrade construction. In accordance with the ROD, HHE located in the South Plants Central Processing Area were excavated to a maximum depth of 5 ft. below grade and removed. HHE located in the South Plants Balance of Areas was excavated to a maximum depth of 10 ft. below grade and removed. Prior to the conclusion of Phase 2, Part 1 it was determined that final subgrade contours required recontouring, and as a result, final subgrade contours were not achieved during Phase 2, Part 1.

Phase 2, Part 2 was developed for the completion of recontour work to achieve final subgrade contours. During implementation of Phase 2, Part 2, interim subgrade boundaries and contours were approved to allow continued use of 7th Avenue for access to Building 312 and also to improve surface water drainage during the interim period between subgrade and cover construction. As part of Phase 2, Part 3, the entire subgrade will be surveyed and improved as needed to achieve the design boundary requirements.

South Plants Soils Phase 2 is comprised of the following 25 ROD-identified Sites: SPSA-1A, SPSA-1G, SPSA-2A, SPSA-2B, SPSA-2C, SPSA-2D, SPSA-2E, SPSA-3A, SPSA-3C, SPSA-3E, SPSA-4A, SPSA-4B, SPSA-5B, SPSA-6, SPSA-7A, SPSA-7B, SPSA-7C, SPSA-8A, SPSA-8B, SPSA-8C, SPSA-9A, SPSA-9B, SPSA-10, SPSA-11, SPSA-12c.

Remediation at the 25 sites involved excavation of HHE soil, Biota Exceedance Soil, munitions debris soil, agent screening, MEC clearance, excavation and/or grouting of chemical sewers, demolition of one structure and foundations, hazardous material abatement, removal of underground storage tanks and removal or grouting of underground storage tank-associated piping, placement of backfill and grading fill (gradefill) to soil cover subgrade elevations, monitoring well abandonment, monitoring well lowering and extension, and placement of temporary revegetation. Process water lines and sanitary sewers were excavated and grouted when encountered during excavation. The HHE Soil was transported to the HWL for disposal. Biota Soil was consolidated within the South Plants soil cover boundary.

Foundations remaining from structures demolition were addressed consistent with the ROD requirements and detail provided in the South Plants Phase 2 design. All foundations from the Agent History Group structures were removed and disposed in the HWL. Foundations located within the South Plants cover areas were cracked and left in place unless removal was required where contaminated soil was located beneath the foundations. All foundations located outside the cover areas were removed. Foundations from the Significant Contamination History Group structures were disposed in the HWL. Foundations from the Other Contamination History Group were removed and used as backfill/gradefill within the South Plants cover areas or were disposed in Basin A.

Disposal of contaminated soil and debris in the HWL was documented using a waste tracking system as specified in RWMP. During Phase 2, Part 1, 150,932 cy of contaminated soil was disposed in the HWL and approximately 343,295 cy of Biota Soil was consolidated within the South Plants soil cover boundary.

To meet requirements of the On-Post ROD, a confirmatory sampling program was developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 96 confirmatory soil samples were collected during Phase 2, Part 1, and approximately 34,235 cy of CSV was excavated based on the sample results. One confirmatory sample was collected during Phase 2, Part 2 and no CSV was excavated. All soils removed were verified by pre- and post-excavation surveys.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The integrated sampling results indicated that there were no action levels exceeded requiring PPE upgrade during the South Plants Balance of Areas and Central Processing Area Phase 2, Parts 1 and 2. However, real-time air monitoring conducted outside of the exclusion zone on April 11, 2002 did indicate an exceedance of the DBCP action level that required upgrading of the PPE in this area and incorporation of this area into the exclusion zone.

On October 1, 2002, the RVO was verbally notified by the PMC of chloroform concentrations above expected values at AQ5, CRABS1, M436S, and MBHS in air samples collected over the time period of September 11-12. A written summary of the September 11-12 results was provided to RVO on October 2 and forwarded to the Regulatory Agencies. No chloroform Air Action Levels were exceeded at AQ5 as demonstrated by the data from this sampling event.

On October 7, 2002, the contract analytical laboratory exercised the expedited notification process by advising the RVO of a preliminary result indicating an elevated chloroform concentration measured on October 1, 2002 at AQ5. All three Air Action Levels at AQ5 were simultaneously exceeded by this detection. The RVO immediately shut down the suspected emitting portion of the project and notified the Regulatory Agencies. The decision to suspend the project was made in response to AQ5 air monitoring results, a previous elevated chloroform measurement at the Montbello High School sampling location on September 12, 2002, and corresponding elevated concentrations at several on-post sampling locations (as described below). The suspected chloroform source area near Buildings 511 and 514 was covered with 1 ft. of soil while other South Plants remediation activities resumed. On October 18, 2002, CSV excavation was suspended due to elevated chloroform measurements collected with the Hapsite® GC/MS. A revised excavation and air monitoring approach for removing the remaining CSV was proposed by the RVO and agreed to by the RMA Council. This revised approach was incorporated into the project plans and specifications (FWENC 2002a).

During work in the South Plants Central Processing Area, there were no COC detections above established acute criteria levels. However, the annual air budget for chloroform, which is based on chronic air criteria, was exceeded at AQ5. Chloroform measurements exceeded the annual air budget at AQ5 by 17 percent. The majority of the budget consumption occurred on two sampling days, September 12 and October 1. After October 1, there were three low-level detections. Further analysis of these events, including analysis of data collected from interior monitoring locations, real-time instrumentation, and review of meteorological conditions indicates that the majority of the chloroform detections at AQ5 were due to the remedial activities in South Plants Central Processing Area.

Chloroform measurements at AQ1 exceeded the annual air budget by 2 percent. However, chloroform budget consumption at AQ1 was primarily due to low-level detections at the site throughout the year. It is believed that the majority of the detections at AQ1 are from off-site sources, although there may have been some influence due to activities at the South Plants Central Processing Area project. However, source assessment of chloroform detections at AQ1 was difficult due to the suspected presence of nearby off-site sources based on historical detections of chloroform at low levels along with known on-site sources.

A single elevated concentration of chloroform (15.1 ug/m^3) and two subsequent low detections (less than 0.6 ug/m^3) were detected at Montbello High School. These detections were attributed to the South Plants excavation because they coincided with elevated concentrations on RMA during excavation of chloroform-contaminated soil and because chloroform is generally not detected at the MBHS air monitoring station.

Although the chloroform annual air budget was not exceeded at AQ3, chloroform detections at AQ3 suggested impacts from the South Plants Central Processing Area. Approximately 86 percent of the chloroform annual air budget was consumed at AQ3. There were no detections of chloroform at AQ3 in 2001. The elevated levels observed at AQ3 were likely due to placement of South Plants Central Processing Area soil and debris in the HWL.

Response actions and notification procedures were conducted in accordance with the Sire-Wide Air Quality Monitoring Program Plan (SWAQMP) (TTECI 2006c). Since chloroform concentrations at AQ5 exceeded the chloroform annual air budget, RVO suspended the project and worked with the Regulatory Agencies to develop corrective actions, as provided by the SWAQMP. These corrective actions included additional excavation controls and monitoring requirements. The Regulatory Agencies approved the corrective actions and the project resumed. Chloroform emissions for the remainder of the project were minimal.

Although the chloroform concentrations at AQ5 exceeded the chloroform annual air budget, no significant public health impacts resulted from this budget exceedance. The annual air budget is an operational limit based on either cancer or non-cancer chronic air criteria developed to ensure that program (i.e., the 15-year-long soil remediation) health risk goals contained in the SWAQMP are attained. At the time of the South Plants Central Processing Area project, the annual air budget was defined as the average annual air concentration equivalent to a theoretical cancer risk of 1×10^{-8}, or 1/15th of the 1×10^{-6} individual chemical program cancer risk goal. This means that the chloroform air budget exceedance at AQ5 during 2002 (i.e., 8×10^{-8}) represented less than 8 percent of the program cancer risk goal for chloroform. The first exceedance of the chloroform annual air budget was in 2002. Chloroform concentrations at AQ5 during each of the four previous years of remediation were well below the chloroform annual air budget. Therefore, the cancer risk estimate for chloroform for the remediation to-date (i.e., 1998 through 2002) at AQ5 was 2 x 10^{-7}, which represents 20 percent of the program risk goal for chloroform.

Enhanced monitoring was also performed during excavation of the DBCP soil blocks in the South Plants Central Processing Area. Although DBCP was detected 13 times at monitoring stations located near excavation activities in the South Plants Central Processing Area and one time at the HWL, there were no DBCP measurements at visitor or fence line monitoring stations in excess of the established acute, chronic carcinogenic, or chronic non-carcinogenic criteria.

A review of the events leading up to and including the annual air budget exceedance for chloroform at AQ5 was conducted. On March 5, 2003, an Air Coordination Group South Plants Central Processing Area Remediation Review was held with the RVO, PMC, EPA, CDPHE and TCHD. The discussion included issues associated with project planning and evaluation, communication, response actions and the SWAQMP. Because the elevated chloroform emissions were a result of excavation in a historical spill area, RVO and the Regulatory Agencies agreed to conduct a pre-operational readiness review of both odorous and nonodorous chemical historical incident/spill documentation prior to commencing with future projects. The spill area was also a potential MEC area and MEC inspection/screening activities were conducted which greatly increased material handling and the resulting emissive surface area. It was agreed that the project planning process should account for emissions from these types of activities. Finally, the RVO and the Regulatory Agencies have developed a number of revisions in the SWAQMP Plan to improve communications and clarify response actions for future projects.

Temporary seeding was placed on all South Plants Balance of Areas and Central Processing Area - Phase 2, Part 1 sites in the interim period prior to subgrade recontouring.

South Plants Soils Remediation Project Phase 2 has been separated into subparts for completion of remediation and completion of cover construction. Phase 2, Parts 1 and 2 require no caps, covers or treatment facilities, therefore no long-term O&M are required at this time since the South Plants soil covers have yet to be completed. Long-term O&M requirements will be discussed in the Phase 2, Part 3 CCR that will document final construction of the 3.25-ft. and 4.5-ft. South Plants soil covers.

A CCR has been prepared for South Plants Balance of Areas and Central Processing Area Soil Remediation Project - Phase 2, Part 1 and Part 2 and approval is expected in early 2007. The CCR is expected to document that remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies are fully functional.

4.3.1.5 Section 36 Balance of Areas Soil Remediation #36

The selected remedy in the On-Post ROD for the Section 36 Balance of Areas component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and UXO debris and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover and the human health excavation area is backfilled with on-post borrow material. Prior to excavation, a geophysical survey is conducted to locate potential UXO. Any UXO encountered will be*

excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Caustic washing and landfill of any agent-contaminated soil found during monitoring. The former human health exceedance area is covered with a 2-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover."

The selected remedy in the On-Post ROD for the Chemical Sewers component of the soil remedy requires:

> *"For sewers located outside the South Plants Central Processing Area and Complex Trenches areas, sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced."*

The selected remedy in the On-Post ROD for the Ditches/Drainage Areas component of the soil remedy requires:

> *"Excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for the Surficial Soil component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A ...of and soil posing a potential risk to biota from this medium group.... The consolidated material is contained under the Basin A cover... and the human health exceedance area is backfilled."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The Section 36 Balance of Areas Soil Remediation included demolition of structures. The RAOs and selected remedy in the On-Post ROD for the structures medium group are presented in Section 4.4.

The ROD remediation standards that apply to the project includes:

> *"Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
>
> *Ensure excavation of all identified ... munitions debris and disposal in the on-post RCRA landfill.*
>
> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*

Interrupt exposure pathway by permanently plugging all chemical sewer lines and manholes not excavated.

Certify 3X decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.

Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.

Meet air quality and odor standards that are ARARs."

The ROD goals that apply to the project include the following:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

The sites included in the Section 36 Balance of Areas include CSA-1b, CSA-2a, CSA-4, NCSA-1g, CSA-3, NCSA-6b, NCSA-6a, CSA-2b, NCSA-1c, NCSA-1f, NCSA-1d, surficial soil exceedance Sites, Priority 1 (P1) Soil Sites, a Priority 2 (P2) Soil Site, CSA-1d, and the Complex (Army) Disposal Trenches P1 Soil Site.

During the design of this project, new information obtained from detailed review of project documents and additional soil sampling resulted in changes proposed by the Army to the chemical sewer excavation, specific cover requirements and excavation volumes. The remedy changes were detailed in an ESD (FWENC 2003b). The changes enhanced the effectiveness of the remedy, but did not alter the overall hazardous waste management approach that was selected in the On-Post ROD. The combined changes to the remedy were:

- Adding four chemical sewer lines not identified in the On-Post ROD to be excavated and disposed of in the on-post HWL.
- Reducing the extent of soil excavation associated with the chemical sewers removal since analysis of soil samples taken adjacent to existing and previously removed sewer lines did not indicate HHE soil remaining in place, with the exception of portions of line 1. Verification sampling was conducted to ensure no HHE soil remained in place.
- Deleting the requirement for the ROD-identified 1-ft. and 2-ft. soil covers based on design soil sampling and a requirement to excavate all contaminated soil identified during design or post-excavation sampling.
- Documenting changes to project remediation boundaries and volumes.

As a result, remediation at these sites included:

- removal of HHE soil, ROD designated potentially agent-contaminated soils, and munitions debris and associated soils and disposal in the HWL
- removal of Biota soil, P1 soil, and Debris Piles and disposal in Basin A
- plugging and/or removal of chemical sewer lines and designated HHE soil and disposal in the HWL

- removal of a length of the freeze protection berm, underlying Biota and P1 soil, and utilities associated with the Complex (Army) Disposal Trenches groundwater extraction system with the disposal of the Biota soil, P1 soil, freeze protection berm, electrical line and communication line in Basin A and disposal of the of the pipe used to convey the contaminated groundwater in the HWL
- demolition of several above and below ground structures and miscellaneous items and disposal in either the Basin A or the HWL
- backfill of HHE and chemical sewer excavations, and structures demolition areas
- ripping P2 soil areas
- revegetation in accordance with the ROD requirements

In addition, during implementation of the Section 36 Balance of Areas project, field observations of stained and odorous soils and post-excavation sampling results suggested that all contaminated soil could not be reliably located and removed as required by the ESD. Therefore, a portion of the Section 36 Balance of Areas project area adjacent to the Shell Disposal Trenches, where stains and odors were observed, has been transferred to the Shell Disposal Trenches project for remedy completion. This portion of the revised remedy, now a part of the Shell Disposal Trenches project, is documented in an ESD for the Shell Disposal Trenches project (TTECI 2006d).

Disposal of contaminated soil, munitions debris and associated soil, ROD-designated potentially agent contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. The total volumes of contaminated soil and munitions debris will be provided in a future FYRR when the project CCR has been finalized.

During project implementation, in an effort to ensure protectiveness, evaluation of isolated detections of contaminants located at greater depths was performed. This effort identified soils exceeding acute Site Evaluation Criteria that, in the absence of additional institutional controls, warranted remediation. As a result, excavation of this soil and disposal in the HWL was incorporated into this project.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. In two instances during the implementation of this project permissible exposure limits were exceeded, once for respirable dust and once for respirable quartz. In each instance engineering controls and respiratory PPE were reviewed and where appropriate, modified.

A CCR has not yet been prepared for the Section 36 Balance of Areas project. No caps, covers, or treatment facilities are required by the ROD (as modified by the Section 36 Balance of Areas ESD for this remediation project). Long-term O&M is required for that part of the project within the Army-maintained area.. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs.

4.3.1.6 Basin F Wastepile Remediation #43

The selected remedy in the On-Post ROD for the Basin F Wastepile component of the soil remedy requires:

> *"Excavation of approximately 600,000 BCY of principal threat soil and liner materials from the wastepile and containment in dedicated triple-lined landfill cells at the on-post hazardous waste landfill facility. Excavation is conducted using vapor- and odor-suppression measures as necessary. If the wastepile soil fails EPA's paint filter test, the moisture content of the soil will be reduced to acceptable levels by using a dryer in an enclosed structure. Any volatile organics (and possibly some semivolatile organics) released from the soil during the drying process are captured and treated; however, the main objective of this process is drying. Prior to excavation of the wastepile, overburden from the existing cover is removed and set aside. The excavation area is backfilled with on-post borrow material and stockpiled overburden."*

The ROD remediation standards that apply to the project include the following:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Ensure dried material passes EPA paint filter test.*
>
> *Comply with requirements of Basin F closure plan and design documents.*
>
> *Control emissions and odors for Basin F Wastepile excavation and Former Basin F remediation, in accordance with Basin F closure plan and design documents.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD goals that apply to the project include the following:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

During preparation of and response to comments on this FYRR, remediation of the Basin F Wastepile began. The Basin F Wastepile Project involves excavation of the existing wastepile and transport of the contaminated soil, liner and cap material and other contaminated material to the ELF for disposal. Odor controls are implemented during all contaminated material handling to mitigate odors from operations reaching the fenceline. A slow start to operations was used to verify effectiveness of the odor controls. Stormwater from all operations is being collected for treatment and disposal either on-site or off-site depending on level of contamination. Leachate continues to be pumped from the Wastepile sumps until the sumps are removed. The wastepile area will be backfilled with soil after all contaminated material, liner systems and CSV soil has been removed.

A drying facility was constructed prior to initiation of Wastepile excavation. The drying facility is used as the location for blending an absorbent or drying agent with wet Wastepile material which fails the paint filter test. The drying facility is equipped with an air handling unit/activated carbon filtration system to remove odors and volatile organics from the air exhaust of the building. The drying facility will be demolished following completion of the Former Basin F Principal Threat Project.

4.3.1.7 Basin F and Basin F Exterior Remediation Part 1 #45

The selected remedy in the On-Post ROD for the Surficial Soil component of the Basin F and Basin F Exterior Remediation Phase 1 requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of Former Basin F of soil posing a potential risk to biota from this medium group.... The consolidated material is contained under the Basin A cover or Basin F cap, and the human health exceedance area is backfilled."*

The selected remedy in the On-Post ROD for the Sand Creek Lateral component of the Basin F and Basin F Exterior Remediation requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standards that apply to the project include:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the Administrative Record.*
>
> *Control emissions and odors for Basin F Wastepile excavation and Former Basin F remediation, in accordance with Basin F closure plan and design documents.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD goals that apply to the project include the following:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The Basin F Exterior – Part 1 project is comprised of three sites: Deep Well Injection Site (NCSA-4a); Basin F Exterior Soil Site (NCSA-4b); Sand Creek Lateral Site (NCSA-5c). Part 2 will include additional biota soil removal from NCSA-4b and construction of a RCRA-equivalent cover over Former Basin F.

Remediation at the three sites involved excavation of HHE and biota risk soils, demolition of subgrade structures encountered during excavation (i.e., footers, headwalls, manholes, vitrified clay pipe), backfilling and regrading, and surface revegetation. Biota risk soil and debris were disposed in Basin A or the HWL. All HHE soil and debris were transported to the HWL for disposal. The design allowed disposal of specific areas of biota risk soil in the HWL. This exception was intended to streamline constructability by allowing biota risk soil and HHE soil to be commingled during excavation of irregular shapes within contiguous HHE and biota risk soil excavations.

During project implementation, in an effort to ensure protectiveness, evaluation of isolated detections of contaminants located at greater depths was performed. This effort identified soils exceeding acute Site Evaluation Criteria that, in the absence of additional institutional controls, warranted remediation. As a result, excavation of this soil as CSV and disposal in the HWL was incorporated into this project.

Disposal of contaminated soil was documented using a waste tracking system as specified in the RWMP. A total of 168,424 cy of contaminated soil was disposed in the HWL during the course of this project. This soil included 129,449 cy of HHE soil, 7,990 cy of biota risk soil, 18,955 cy of CSV, and 12,030 cy of additional soil removed per the direction of the Regulatory Agencies. Regulatory Agencies directed the removal of CSV and the additional soil based on confirmatory sample results, odor, and soil staining. The 12,030 cy of additional soil identified for removal by the Regulatory Agencies was located within the ROD-defined limits of Former Basin F and therefore is not considered CSV. Approximately 73,368 cy of biota risk soil was disposed in Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 72 confirmatory soil samples were collected during the project and 18,955 cy of CSV soil was excavated based on the sample results. All soils removed were verified by pre-and post-excavation surveys.

The project sites were seeded with locally adapted perennial vegetation upon completion of the remediation activities.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the Basin F Exterior – Part 1 project.

A CCR was approved on October 12, 2006 (TTECI 2005d). As documented in the CCR, remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO officials and Regulatory Agencies, are compliant with the ROD and functioning as intended. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. There are no early indicators of potential remedy failure.

4.3.2 Operating On-Post Soil Remedies

4.3.2.1 Operation of Hazardous Waste Landfill Cells 1 and 2 #7

Construction of the HWL was completed in the fall of 1998 and is discussed in Section 4.3.3.2. The landfill was certified to accept waste in April 1999 and the first waste was received on May 11, 1999. Since opening, the HWL has operated to receive waste from thirty remedy projects. These 30 projects have delivered 142,747 loads of material to the HWL. As of June 1, 2005, the current volume in place in the HWL is 1,749,286 cy of soil, debris, and various other waste streams. This translates to a remaining capacity of approximately 47,610 cy.

As of the summer of 2005, approximately two thirds of the HWL has been covered with intermediate cover and an erosion protection layer meeting specifications as outlined in the HWL Operations Manual. Remaining areas will be covered upon completion of final waste grades.

In June 2004, the HWL began the Interim Operations phase, defined as a time during which the HWL will be accepting waste at a reduced frequency. During the Interim Operations Phase, the HWL is opened as necessary to receive waste from the remediation. Upon completion of this phase of operations and placement of the remaining intermediate cover, final cover placement will begin. At that time, the Final CCR for HWL Operations will be completed. Completion of the CCR is expected in late 2007.

Consistent with the CAMU Designation Document (HLA 1996b) The placement of waste is governed by Part 265, Subpart B, C, D and E of 6 the Code of Colorado Regulations 1007-3, Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities. The specific operating requirements to ensure compliance with these regulations are presented in the HWL Operations Plan (FWENC 2001c) as reviewed and approved by the Regulatory Agencies.

Waste receipt into the HWL complies with On-Post ROD requirements that dictate the final disposal of waste material from remediation projects. The details of these On-Post ROD requirements are contained in the RWMP that clearly delineate the disposal of waste materials in the HWL or Basin A. The RWMP also provides guidance with respect to waste tracking in providing procedures and forms for ensuring the delivery of waste material to the proper location. This waste tracking is performed electronically with a backup system comprised of paper forms.

In 2001, DIMP was unexpectedly detected in the leak detection water of Cell 2 of the HWL. After confirmation over several sampling events, an investigation was undertaken to confirm that the primary liner of the HWL has not been compromised and to evaluate the source of the DIMP in order to avoid use of DIMP-contaminated materials during ELF construction (RVO 2002a).

First, the absence of DIMP in samples from the leachate collection system allowed the investigators to quickly confirm that the primary liner for the HWL had not been compromised and that leakage of leachate from the leachate collection system into the leak detection layer could be ruled out as the source of contamination.

Second, the team identified three sources or pathways of contamination:

- Large volumes of South Lakes water or infiltrated groundwater delivered through the nonpotable water supply and used to condition clay in the primary liner
- Borrow Area 5 clay used for the primary liner that was underlain by a DIMP groundwater plume
- Sanitary Sewer line traversing Borrow Area 5 and acting as a conduit from DIMP contamination originating in the North Plants vicinity

Each of these possible sources was evaluated using both existing and newly collected analytical data and available empirical evidence. As a result, the sanitary sewer line traversing Borrow Area 5 was determined to be the most likely source and pathway for the DIMP identified in the HWL leak detection system.

This conclusion allowed the RVO to modify its approach to ELF liner construction in two ways. First, the portion of Borrow Area 5 delineated for liner construction is located a minimum of 50 ft. from any pre-existing sanitary sewer alignment. Second, although only a very remote possibility, the depth of excavation for borrow material would maintain a minimum distance of 10 ft. above the historic high groundwater table. For further discussion see Section 6.3.5.

During the operation of the HWL no serious event required implementation of the Contingency Plan. The requirements of the On-Post ROD and CAMU Designation Document as stated in the HWL Operations Plan are currently being met by the O&M activities and there are currently no early indicators of potential remedy failure.

4.3.2.2 Operation of Hazardous Waste Landfill Wastewater Treatment Unit #10

Construction of the Hazardous Waste Landfill Wastewater Treatment Unit (LWTU) was completed in the fall of 1998 and is discussed in Section 4.3.3.2. The LWTU has been operated to support HWL operations. It has successfully treated all stormwater, leachate and decontamination wastewater from HWL operations.

The discharge of treated water from the facility is monitored for compliance with the requirements of the CERCLA Compliance Document (CCD)(EPA 2002a). The CCD comprises a discharge authority issued by the EPA that established the self-monitoring requirements of the treatment system including regulatory basis, discharge standards, monitoring requirements, and reopener provisions. Quarterly Discharge Monitoring Reports are required to be submitted to the Regulatory Agencies to certify compliance with the CCD and/or report any noncompliance events. The treatment plant has been operated in full compliance with the administrative requirements of the CCD, including the timely submission of the Discharge Monitoring Reports.

The CCD contains provisions that require modification of discharge control requirements in the event of changes to water quality standards, wasteload allocation, water quality management plan, monitoring results, and/or the development of new treatment technology-based limits. Two of these provisions requiring modification of the CCD were noted during the previous FYR of LWTU operations conducted in 1999. Accordingly, the CCD reopener provisions were invoked on December 18, 2002 that resulted in a revised CCD being issued by the EPA. The changes to the Code of Colorado Regulations addressed: 1) interim water quality standards adopted by the State of Colorado under Colorado Water Quality Standards 5 Code of Colorado Regulations

1002, Regulation 31 and Regulation 38 for stream segments that included the receiving waters of the treated effluent from the LWTU; 2) deletion of analytes that had no current or historical detection above the discharge standards; 3) updating analytical detection limits to industry-accepted values; and 4) reducing the frequency from a monthly to a quarterly submittal of Discharge Monitoring Reports.

Significant incidents during operation of the LWTU over the past FYR period include the following:

- An accidental overflow of the HWL Lift Station that resulted in a release of wastewater outside of the lift station containment berm. Investigation indicated malfunction of the level sensor that prevented the start of the lift station pumps to evacuate the full sump. Eventually, the liquid contents of the lift station spilled over the containment berm. The incident was discovered soon enough to minimize the quantity of wastewater discharged outside the containment berm. The response to this incident involved the excavation of soils impacted by the overflow and disposal of the excavated soil in the HWL.
- A potential exceedance of the discharge standard for nitrite was discovered in a batch of wastewater treated at the LWTU. Investigation indicated that the concentration in exceedance of the standard did not correlate with significantly lower detections in the untreated influent. It was further concluded that the exceedance concentration did not correlate with the stoichiometric conversion of ammonia nitrogen to nitrite by the Nitrosomonas bacteria under aerobic conditions. Based on these findings, the investigation concluded that the nitrite analytical data were anomalous and unsubstantiated. No further actions were required following the mandated notification of the incident to the Regulatory Agencies.

Based on the information provided above, operation of LWTU has been in accordance with On-Post ROD requirements as specified in the LWTU Operations Plan (MKE 1999).

4.3.2.3 Operation of Basin A Consolidation and Remediation Area #14

The selected remedy in the On-Post ROD for the Basin A Consolidation Area component of the soil remedy requires:

> *"Construction of a soil cover consisting of a 6-inch-thick layer of concrete and a 4-ft.-thick soil/vegetation layer over the principal threat and human health exceedance soil and soil posing potential risk to biota, and consolidation of debris and soil posing a potential risk to biota and structural debris from other sites. No RCRA-listed or RCRA characteristic waste from outside the AOC will be placed in Basin A. Any UXO encountered will be removed and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process."*

During the Basin A design, preliminary information available from the on-site RCRA-Equivalent Cover Demonstration Project was reviewed for consideration of specific soil types that would be suitable for the Basin A cover construction to minimize infiltration. As a result, the Basin A design included specific information on the soil types for cover construction that are similar to the suitable soil types for RCRA-equivalent covers (RVO 1997b). Further discussions with the federal, state and local Regulatory Agencies resulted in a decision to upgrade the Basin A soil cover to a RCRA-equivalent cover, maximizing the long-term protectiveness for the waste containment area (RVO 2002b).

The Basin A design analysis also included an evaluation of possible alternatives for the human/wildlife barrier design including the ROD-described six-inch-thick concrete layer. The conclusions reached in the Basin A design included a recommendation for an 18-inch-thick crushed concrete barrier to serve as a human/wildlife barrier (RVO 1997c). Based on discussions with the USFWS, an 18-inch-thick crushed concrete barrier would be more effective in limiting intrusion by burrowing mammals than the six-inch-thick, concrete layer. Also, the Basin A design resolution included a provision for high visibility warning tags (later changed to tape) within the cover soil to provide an additional layer of subsurface warning to humans. Subsequently, the high visibility warning tape was eliminated in favor of high visibility (orange) geotextile.

Work performed to prepare Basin A for operation included the construction of a foundation layer of approximately 1 to 3 ft. depth to prevent contact of waste hauling and placement equipment with potential UXO in the Basin. This foundation layer was comprised primarily of biota-exceedance soil that originated from the areas of the CAMU. Construction of the 1-ft. foundation layer in Basin A is described in Section 7.1.3.1.2 of the 2000 FYRR (PMRMA 2000a). UXO is discussed in Section 4.5.1.3.

Since its opening, Basin A has operated to receive waste from the 25 projects. The 25 projects delivered 74,625 loads of waste material to Basin A. The total in-place volume of gradefill and waste materials placed Basin A is 1,888,269 cy of waste and gradefill materials.

In July 2004, Basin A began the Interim Operations Phase, defined as a time during which Basin A will be receiving waste at a reduced frequency. In addition, Basin A is currently transitioning to the "notch" area for placement operations so that the remaining areas can be relegated to the placement of gradefill to achieve precover subgrade. This will allow Basin A to continue to receive waste while the majority of the cover is being constructed. The approximate volume required to fill the notch is 256,000 cy. Upon completion of the subgrade, the Basin A Operations Final CCR will be completed. At that time, placement operations will continue in the notch to accommodate the last remaining wastes from RMA projects. A separate CCR will be written to capture these operations. As of September 1, 2006 approximately 166,000 cy or airspace remains with delivery of approximately 66,000 cy expected from the Miscellaneous Structures Phase III project.

Waste receipt into Basin A complies with On-Post ROD requirements that dictate the final disposal of waste material from remediation projects. The details of these On-Post ROD requirements that clearly delineate the disposal of waste materials in the HWL or Basin A are contained in the RWMP. The RWMP also provides guidance with respect to waste tracking in providing procedures and forms for ensuring the delivery of waste material to the proper location. This waste tracking is performed electronically with a backup system comprised of paper forms.

The requirements of the Basin A Operations Plan (PMRMA 2000b) are currently being met by the O&M activities and there are currently no early indicators of potential remedy failure.

Basin A is therefore operating in accordance with requirements of the On-Post ROD as stated in the Basin A Operations Plan that has been reviewed and approved by the Regulatory Agencies.

4.3.2.4 Borrow Area Operations #47a

The RMA remedy as described in the ROD will require approximately 12 million cy of borrow materials to backfill excavations, build structural fills, establish cover grades, and construct liner and cover components. The RVO maintains a tracking plan (TTECI 2005e) that identifies those areas within the RMA boundary where borrow operations would be appropriate, that estimates the material types available at the sources, that estimates the sizes of areas impacted by borrow excavations, that allocates and manages borrow area operations, that provides operation alternatives and that identifies operational issues.

It should be noted that the Biological Advisory Subcommittee (BAS) has identified potential biota residual risk areas and classified them as containing either P1 or Terrestrial Residual Ecological Risk (TRER) soils. These soils are located within the upper 1 ft. of the soil profile in these areas. Borrow area boundary selection was focused on inclusion of areas containing P1 soils. P1 borrow soils will not be used as top soil or liner soil, nor will it be placed within the upper 2 ft. backfilled excavations or cap/cover systems.

Several issues related to unexpected discovery of contamination have been identified during borrow area operations or remediation activities adjacent to borrow areas. In 2003, an empty E-139 bomblet and former burn area were discovered during borrow area characterization efforts in Borrow Area 10. As a result, the burn area was delineated and added to the Munitions Testing Remediation Project Part II. Further investigation included performing a surface sweep (assisted by hand-held magnetometer/ electromagnetic detectors) of the area surrounding the location of the previously recovered munitions debris (200' x 200' grid). No additional military munitions-related items were encountered. The area characterized as a potential surface-burn site was assessed and it was determined that it was likely a trash and debris burn site (there was no evidence of previously burned military munitions). The remaining burned material in this area was removed (approximately 12' x 12' surface scrape) and placed in the HWL.

High pH soil was also identified in Borrow Area 10 during borrow area characterization efforts. This high pH soil, pH greater than 8.8, was deemed unsuitable for cover soil construction and was identified for removal and use as common backfill or gradefill. This soil was removed during the Complex (Army) Disposal Trenches subgrade construction and used as gradefill beneath the Complex (Army) Disposal Trenches RCRA-equivalent cover.

During Subcontractor operations to remove P1 soil from Borrow Area 9A (Parcel 4) munitions debris and MEC were recovered. Upon recovery of these military munitions-related items UXO personnel were added to observe future intrusive operations in borrow areas contiguous to the historic M47 (incendiary bomb) static-test firing pad (near the intersection of 8th Ave. and the North Plants Haul Road). This action led to the additional recovery of MEC, which subsequently led to a Department of Defense Explosives Safety Board-approved munitions response action for Borrow Area 9A (Parcel 2) and Site CSA-2c southwest/northwest. Given the nature of operations performed at the M47 test pad, the munitions response action for the site was added to the scope of the Munitions Testing Remediation Project. This munitions response action is intended to address the potential to recover MEC during future intrusive operations in Borrow Area (Parcel 2) and (Parcel 3).

4.3.2.5 Basin F Wastepile Operations and Management #65

The original construction and establishment of a routine O&M schedule for the Basin F Wastepile is discussed in detail in the IRA Summary Report titled Basin F Liquid, Sludge, and Soil Remediation - Element One, Basin F Wastepile (EPA 2000b). Ongoing O&M of this wastepile is critical to the successful implementation of the remedy. Routine O&M has adhered to all provisions of the On-Post ROD with leachate being regularly collected and shipped off-site for disposal in accordance with RCRA.

Cell 2 of the primary sump system is not operating as designed. Very little leachate is being collected in cell 2 of the primary sump system while larger volumes are being collected by the secondary sump system. The secondary system is functioning as designed. However, it should be noted that the leachate and leak detection volume currently being generated (25,641 gallons in calendar year 2004) has now leveled off after consistently and dramatically declining from what it has been in the past (24,650 gallons in calendar year 1999, 81,336 gallons in calendar year 1990) due to the dewatering of the waste.

The issue of higher-than-expected volumes of leachate being collected in the Subcell #2 secondary sump, compared to the Subcell #2 Primary Sump was identified prior to preparation of the 2000 FYR. Two possible causes for the performance of the Subcell #2 leachate collection systems have been identified. One possible cause is the Subcell #2 primary liner may have a significant breach which allows the entire leachate flow to be intercepted and diverted into the secondary leak detection system. The other possible cause is the Subcell #2 Primary Sump is clogged with salt crystals or fine soil particles, to the extent leachate can not flow into the sump for removal, allowing the leachate to pool on top of the primary liner until the leachate reaches to point of interconnection between the two systems, and flows into the secondary leak detection system.

During this FYR period, RMA has been flushing the Subcell #2 leachate collection system with hot water to dissolved salt crystals presumed to be clogging the sump. These actions temporarily restored leachate flow into the primary sump. However, after each sump flush, the leachate flow into the Subcell #2 Primary Sump would slowly diminish until all leachate flow into the sump stopped again. Over time, the sump flushes became less effective, until the flushing activity was terminated due to ineffectiveness. The clogging of the Subcell #2 Primary Sump seems the more reasonable of the two possible causes for the leachate collection issues in Subcell #2.

During preparation of and response to comments on this FYRR remediation of the Basin F Wastepile began and is discussed in Section 4.3.1.6.

4.3.3 Completed On-Post Soil Remedies

4.3.3.1 Corrective Action Management Unit Soil Remediation Completion and Support #2

In order to begin construction of the HWL, certain soils posing a risk to biota needed to be removed from the footprint of the HWL and from the designated borrow area. Part 1 of the CAMU Soil Remediation used the biota soil to construct the 1-ft. foundation layer required in the Basin A design. As described in Section 7.1.3.1.2 of the 2000 FYRR (PMRMA 2000a), at the close of Part 1, numerous small areas within the original work area were not excavated due to existing structures (e.g., utility poles, sewer manholes, monitoring wells, etc.)(RVO 1998). The CAMU Soils Remediation Completion and Support Project was undertaken as Part 2 to complete unfinished activities remaining at the close of the CAMU Soils Remediation Project.

The selected remedy in the On-Post ROD for the Surficial Soil component of the soil remedy requires:

> *"Excavation and ...consolidation to Basin A ...of soil posing a potential risk to biota from this medium group.... The consolidated material is contained under the Basin A cover...."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standards that apply to the project include:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the Administrative Record.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The project involved remediation at 97 distinct sites originally identified in the ROD as part of NCSA-4b, and revegetation of those sites. Remaining biota soil adjacent to the existing structures was removed and disposed in Basin A. Additional work involved sizing and disposing or recycling debris that consisted of concrete fence post bases, pieces of asphalt pavement, chain-link fence fabric, wooden utility poles and other miscellaneous materials. Scrap metal was recycled at approved recyclers and sized debris was disposed at Basin A.

Disposal of contaminated soils and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. Approximately 2,480 cy of P1 and Biota Exceedance soil and approximately 3,900 cy of miscellaneous debris were disposed Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the CAMU Part 2 project, no confirmatory samples were taken, and no CSV and no CSV soil was removed. All soils removed were verified by pre- and post-excavation surveys.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the CAMU Soils Remediation Completion and Support Project Part 2.

As documented in the CCR (FWENC 2000b), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on September 29, 2000.

4.3.3.2 Construct the Hazardous Waste Landfill Wastewater Treatment Unit #3 and Construct Hazardous Waste Landfill Cell 1 #4

The selected remedy in the On-Post ROD for the HWL requires:

> *"Construction of a RCRA- and TSCA-compliant hazardous waste landfill on-post."*

Additionally, the ROD remediation standards that apply to the construction of the HWL require:

> *"Design landfill to meet state 1,000-year siting criteria.*
>
> *Minimize percolation by limiting the hydraulic conductivity of the compacted clay layer to 1 x 10^{-7} cm/sec or less.*
>
> *Install two composite liners, each consisting of 3 ft. of compacted clay and a synthetic liner.*
>
> *Meet or exceed all RCRA, TSCA, and state requirements*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The On-Post OU Detailed Analysis of Alternatives Dispute Resolution Agreement (PMRMA 1995) specifies that the HWL is a remediation waste management facility and shall be operated as part of a RCRA CAMU. The ROD identifies the HWL as a key component of the CAMU, which consists of the following implementation projects:

- CAMU Soil Remediation Project
- CAMU/Basin A Well Abandonment Project
- HWL Phase I Construction
- LWTU Construction
- CAMU Soils Remediation Completion and Support Project
- Section 26 HHE and Biota Soils Removal Project

- HWL Phase II Construction
- HWL Operations (not complete)
- HWL Cap Construction (not complete)
- HWL Closure (not complete)

A June 1996 Compliance Order (CDPHE 1996) issued under authority of the Colorado Hazardous Waste Management Act, outlines the requirements for construction, operation, and closure of the HWL.

The HWL Phase I Project (Construct the Hazardous Waste Landfill Wastewater Treatment Unit and Construct the Hazardous Waste Landfill Cell 1) involved construction of the following:

- One of two double-composite-lined waste cells (Cell 1)
- Leachate collection system
- Leak detection system
- Perimeter leachate conveyance system
- Wastewater lift station and discharge pipeline
- HWL operational support facilities and decontamination pad
- Stormwater drainage channels and perimeter fence
- Uncontaminated stormwater detention area
- LWTU
- LWTU influent and treated water equalization basins
- LWTU treated water discharge pipeline
- Groundwater monitoring network
- Borrow Area Number 5 (borrow source for clay, structural fill, and cover soil)

The notice to proceed for construction was issued March 3, 1998 and the Final Inspection was completed on April 29, 1999.

A Construction Quality Assurance (CQA)/Construction Quality Control (CQC) program was implemented for the Phase I Project. CQA consisted of planning, assessment, reporting, and quality improvement to provide adequate confidence that the HWL was constructed as specified in the design. CQA activities included confirmatory inspections, independent testing, audits, and evaluations of materials and workmanship to assess conformance to the design drawings and specifications. CQC consisted of monitoring, inspecting, testing, and reporting to determine whether the control of supplies, manufacturers, products, services, site conditions, and workmanship met the design requirements.

Certification reports were prepared upon completion of the Phase I construction activities in compliance with Section 40 CFR 265.19(d) of to document that Phase I of the HWL met the approved design for the project. Final copies of the approved reports were issued to the Regulatory Agencies on April 26, 1999.

The HWL Phase I Project complied with the ARARs. All construction activities were performed "clean" and there was no threat of contaminants being released during excavation, backfill, geosynthetic placement, structures erection or stormwater events.

As documented in the CCR (FWENC 2000c), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This CCR documents only the construction effort, and the construction phase does not require any long-term O&M. However, the property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on September 27, 2000.

4.3.3.3 Section 26 Human Health Exceedance and Biota Exceedance Soils Removal #5

The selected remedy in the On-Post ROD for the Surficial Soil component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A or Former Basin F of soil posing a potential risk to biota from this medium group.... The consolidated material is contained under the Basin A cover or Basin F cap and the human health exceedance area is backfilled."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standards that apply to the project includes:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the Administrative Record.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The Section 26 Human Health Exceedance and Biota Exceedance Soils Removal Project was originally part of the Basin F Exterior Soils Remediation Project. During the late summer months of 1999, the HWL was scheduled to receive a significantly greater amount of ACM than originally anticipated. To mitigate this problem, removal of the Section 26 HHE soil was accelerated to provide necessary cover soils to continue disposal of ACM in the HWL. This portion of the Basin F Exterior Project was separated out to provide additional HHE soils to the HWL operation. The Section 26 Biota soils were also removed at that time.

Because the work was accelerated, the project did not go through traditional design phases. The project scope was based upon a drawing and excavation specification completed by the Corp of Engineers, supplemented with drawings and specifications from similar soil remediation projects that had been approved by the RVO and Regulatory Agencies. The final design went to the Regulators for review concurrent with the procurement process. Regulatory Agency comments were reconciled before fieldwork began, and the final package was issued for construction.

Disposal of contaminated soils and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. Thirteen thousand seven hundred eighteen (13,718) cy yards of HHE soil and miscellaneous debris were disposed in the HWL during the extent of this project, and 4,032 cy of biota soil and road base were disposed in Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, two confirmatory samples were taken and no CSV soil was excavated. All soils removed were verified by pre- and post-excavation surveys.

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. However, the approved design for Section 26 Human Health Exceedance and Biota Soils removal project eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. However, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

At the recommendation of the BAS, NCSA-4b, was resampled using an analytical method capable of detecting concentrations of COCs in the biota risk range (USFWS 2002a). Sampling was performed consistent with the method developed by the BAS for the TRER evaluation by collecting a 5-point composite sample over each area representing a small bird exposure range. This additional sampling indicated that there was contamination remaining at the excavation surface in site NCSA-4b that posed excessive risk to biota. As a result additional biota soil was excavated from this site NCSA-4b. A total of 5,128 cy of CSV soil was excavated and taken to Basin A. This effort was documented in an Addendum to the CCR.

Health and safety sampling and analysis were performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were met or exceeded for the contaminants tested during the Section 26 HHE and Biota Soils Removal Project.

Upon completion of remediation activities, sites were seeded with locally adapted perennial vegetation.

As documented in the CCR (FWENC 2000d), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on October 17, 2000. An addendum to the CCR (RVO 2004d) was approved by EPA on March 30, 2006 for additional CSV soil excavation. The approval of the Addendum occurred after the March 31, 2005 cutoff date for the 2005 FYR; therefore, this project will also be included in the 2010 FYRR.

4.3.3.4 Construct the Hazardous Waste Landfill Cell 2 #6

The selected remedy in the On-Post ROD for the construction of a HWL component of the soil remedy requires:

> *"Construction of a RCRA- and TSCA-compliant hazardous waste landfill on-post"*

Additionally, the ROD remediation standard that applies to the construction of the HWL is to accomplish the following:

> *"Design landfill to meet state 1,000-year siting criteria.*
>
> *Minimize percolation by limiting the hydraulic conductivity of the compacted clay layer to 1 x 10^{-7} cm/sec or less.*
>
> *Install two composite liners, each consisting of 3 ft. of compacted clay and a synthetic liner.*
>
> *Meet or exceed all RCRA, TSCA, and state requirements*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The HWL Phase II Project involved construction of the following:

- The second of two double-composite-lined waste cells (Cell 2)
- Leachate Collection System for Cell 2
- Leak Detection System for Cell 2
- Leachate Collection System / Leak Detection System tie-in to the existing perimeter leachate conveyance system
- Tie-in to Cell 1 at the Center Berm
- Perimeter Access Road

- Cell 2 Excavation and Berm Construction
- Borrow Area 5 Management
- Temporary stormwater drainage channels
- Revegetation

A CQA/CQC program was implemented for the Phase II Project. CQA consisted of planning, assessment, reporting, and quality improvement to provide adequate confidence that the HWL was constructed as specified in the design. CQA activities included confirmatory inspections, independent testing, audits, and evaluations of materials and workmanship to assess conformance to the design drawings and specifications. CQC consisted of monitoring, inspecting, testing, and reporting to determine whether the control of supplies, manufacturers, products, services, site conditions, and workmanship met the design requirements.

Certification reports were prepared upon completion of the Phase II construction activities in compliance with Section 40 CFR 265.19(d) to document that Phase II of the HWL met the approved design for the project.

The HWL Phase II Project complied with the ARARs. All construction activities were performed "clean" and there was no threat of contaminants being released during excavation, backfill, geosynthetic placement, structures erection or stormwater events.

Final revegetation for this project will be accomplished as part of cover construction.

As documented in the CCR (FWENC 2001d), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This CCR documents only the construction effort, and the construction phase does not require any long-term O&M. The property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on April 18, 2001.

4.3.3.5 Shell Disposal Trenches Slurry Wall (construction) #17

The selected remedy in the On-Post ROD for the Shell Disposal Trenches component of the soil remedy requires:

> *"Expansion of the existing slurry wall around the trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be re-evaluated during remedial design. Soil excavated for the slurry wall trench is graded over the surface of the site and is contained under the cap."*

During preparation of and resolution of comments on the 2005 FYRR, an ESD to the Shell Disposal Trenches component of the soil remedy was prepared. This ESD does not affect the slurry wall construction project and documents an expansion of the Shell Disposal Trenches RCRA-equivalent soil cover to include the extent of the former drum storage area south of the Shell Disposal Trenches. In addition, the Shell Disposal Trenches component of the soil remedy was modified to include a 2-ft.-thick soil cover in areas adjacent to the Shell Disposal Trenches. The 2-ft.-thick soil cover area includes approximately 31 acres located between the Shell Disposal Trenches, Basin A and the Complex (Army) Disposal Trenches where stained soils and odors were observed during Section 36 Balance of Areas project implementation. The cover was added as an expansion of the overall Shell Disposal Trenches cover due to field conditions that were considered related to historical disposal activities at the Shell Disposal Trenches.

The ROD remediation standards that apply to the construction of the Shell Disposal Trenches Slurry Wall include:

> *"Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Minimize groundwater flow across the slurry wall with a design goal 1 x* 10^{-7} *cm/sec hydraulic conductivity.*
>
> *Construct slurry wall with sufficient thickness to withstand maximum hydraulic gradient.*
>
> *Construct slurry wall with materials that are compatible with the surrounding groundwater chemistry.*
>
> *Minimize migration by keying the slurry wall in an underlying low permeability strata.*
>
> *Dewater as necessary to ensure containment.*
>
> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The Complex (Army) Disposal Trenches Slurry Wall construction project and the Shell Disposal Trenches Slurry Wall construction project were combined for implementation. Regardless, separate CCRs were written for each construction project. Both construction projects are the first of two phases for their respective projects.

For the Shell Disposal Trenches, the first phase included geophysical surveys for UXO, installation of a working bench and access road, subsurface geophysical exploration to determine depth to bedrock, installation of the slurry wall and installation of groundwater monitoring wells. The design concluded that extraction of groundwater from the Shell Disposal Trenches was not necessary because groundwater was not present in the deepest trench areas.

The second phase for the Shell Disposal Trenches project involves construction of a RCRA-Equivalent cover and 2-ft soil cover.

Real-time monitoring was performed for the chemical agents Sarin (GB), VX, Mustard, and Lewisite during intrusive operations in Section 36. There were no confirmed detections of chemical agents above one Time-Weighted Average. Real-time monitoring was also performed for organic vapors, total nuisance dust, and temperature extremes during intrusive operations in Section 36. The surveys were conducted throughout the work area during various phases of the project. During the performance of the project work, there were no action level exceedances nor were there any detections above the Permissible Exposure Limits.

Final revegetation of this project will be accomplished as part of cover construction.

As documented in the CCR (FWENC 2001e), the construction of this phase of the project has been completed and is operating properly and successfully. As a construction project this portion of the selected remedy is not subject to long-term O&M. The property involved in this project and the waste left in place is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on June 08, 2001.

4.3.3.6 Complex (Army) Disposal Trenches Slurry Wall (construction) #17

The selected remedy in the On-Post ROD for the Complex (Army) Disposal Trenches component of the soil remedy requires:

> *"Installation of a slurry wall into competent bedrock around the disposal trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be reevaluated during remedial design. Soil excavated for the slurry wall trench is graded over the surface of the site and is contained under the cap. Prior to installing the slurry wall and cap, a geophysical survey is conducted to locate potential UXO within the construction areas. Any UXO encountered will be removed and transported offpost for detonation (unless the UXO is unstable and must be detonated on-post) or other demilitarization process."*

The ROD remediation standards that apply to the construction of the Complex (Army) Disposal Trenches Slurry Wall include:

> *"Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Minimize groundwater flow across the slurry wall with a design goal 1 x 10EE-7 cm/sec hydraulic conductivity.*
>
> *Construct slurry wall with sufficient thickness to withstand maximum hydraulic gradient.*
>
> *Construct slurry wall with materials that are compatible with the surrounding groundwater chemistry.*
>
> *Minimize migration by keying the slurry wall in an underlying low permeability strata.*
>
> *Dewater as necessary to ensure containment.*
>
> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The Complex (Army) Disposal Trenches Slurry Wall construction project and the Shell Disposal Trenches Slurry Wall construction project were combined for implementation. Regardless, separate CCRs were written for each construction project. Both construction projects are the first of two phases for their respective projects.

For the Complex (Army) Disposal Trenches the first phase included geophysical surveys for UXO, installation of a working bench and access road, subsurface geophysical exploration to determine depth to bedrock, installation of the slurry wall, installation of the groundwater extraction trench and installation of groundwater monitoring wells. The design concept found in the ROD incorporated a slurry wall that fully enclosed the Complex (Army) Disposal Trenches. However, it was determined during the design phase that a closed wall was not necessary to achieve the goal with groundwater extraction systems in place.

The second phase for the Complex (Army) Disposal Trenches project involves construction of a RCRA-Equivalent Cover.

Real-time monitoring was performed for the chemical agents GB, VX, Mustard, and Lewisite during intrusive operations in Section 36. There were no confirmed detections of chemical agents above one Time-Weighted Average. Real-time monitoring was also performed for organic vapors, total nuisance dust, and temperature extremes during intrusive operations in Section 36. The surveys were conducted throughout the work area during various phases of the project. During the performance of the project work, there were no action level exceedances nor were there any detections above the Permissible Exposure Limits.

Final revegetation of this project will be accomplished as part of cover construction.

As documented in the CCR (FWENC 2001b), the construction of this phase of the project has been completed and is operational and functional. As a construction project this portion of the selected remedy is not subject to long-term O&M. The property involved in this project and the waste left in place is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 03, 2001. EPA approved an addendum to the CCR, indicating that the dewatering system was "Operational and Functional" on September 30, 2002 (FWENC 2001a).

4.3.3.7 Toxic Storage Yards Soil Remediation #19

The selected remedy in the On-Post ROD for the Toxic Storage Yards component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil. Any agent contaminated soil found during monitoring is caustic washed and landfilled. The excavated areas is backfilled with on-post borrow material. The New Toxic Storage Yards are used as a borrow area for both low-permeability and structural fill."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The Toxic Storage Yards Soil Remediation included demolition of structures. The RAOs and selected remedy in the On-Post ROD for the structures medium group are presented in Section 4.4.

The ROD remediation standards that apply to the Toxic Storage Yards include:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the Administrative Record.*
>
> *Demolish all structural material identified in the ROD for landfilling or consolidation.*
>
> *Certify 3X level of decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.*
>
> *Ensure disposal 3X-decontaminated soil and structural debris in the on-post RCRA landfill.*
>
> *Removal of asbestos and ACM to attain Toxic Substances Control Act (TSCA) requirements.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The Toxic Storage Yards Soil Remediation Project involved the excavation and landfilling of HHE soil in the HWL, demolition and removal of miscellaneous structures, closure of three wells, chemical agent screening during soil excavation and soil ripping operations, and temporary revegetation of disturbed areas. The three sites remediated include: ESA-3a - Overflow Area for Old Toxic Storage Yard; ESA-3b - Old Toxic Storage Yard; and ESA-3g - Open Storage Area for New Toxic Storage Yard.

During design, the HHE soil excavation volume increased by approximately 1,800 cy over the original On-Post ROD estimate. As a result, a Technical Justification Report was issued in May 1999 to document this HHE soil volume increase (FWENC 1999b).

Health and safety sampling and analysis were performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were met or exceeded for the contaminants tested during the Toxic Storage Yards Soil Remediation Project.

Disposal of contaminated soils and structural/miscellaneous debris was documented using a waste tracking system as specified in the RWMP. Seven thousand eight hundred cy of contaminated soil were disposed in the HWL during this project and approximately 4,500 cy of structural/miscellaneous debris were disposed in Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, sixteen confirmatory samples were taken and no CSV soil was excavated. All soils removed were verified by pre- and post-excavation surveys.

Sites ESA-3a and ESA-3b have been permanently reseeded by USFWS. ESA-3g has been seeded with a locally adapted perennial and will be permanently seeded in the future.

As documented in the CCR (FWENC 2000e), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on June 20, 2000.

4.3.3.8 Existing (Sanitary) Landfills Remediation Section 1 #20

This project addressed remedial actions stated in the On-Post ROD for a distinct portion of the ESL Project. The selected remedy in the ROD for Sanitary Landfills requires the following:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of landfill debris and soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

Additionally, the ROD remediation standard that applies to the sanitary landfills is to accomplish the following:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the aerial and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The original ESL Section 1 project was completed during the first FYRR and is discussed in that report (PMRMA 2000a). However, in 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. However, the approved design for ESL Section 1 (SSA-4) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. However, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

At the recommendation of the BAS, SSA-4 was resampled using an analytical method capable of detecting concentrations of COCs in the biota risk range (USFWS 2002a). Sampling was performed consistent with the method developed by the BAS for the TRER evaluation by collecting a 5-point composite sample over each area representing a small bird exposure range. This additional sampling indicated that there was contamination remaining at the excavation surface in site SSA-4 that posed excessive risk to biota. As a result, additional biota soil was excavated from this site SSA-4. A total of 1,666 cy of CSV soil was excavated and taken to Basin A. One confirmatory sample was collected after excavation of the CSV soil. Backfill was placed at SSA-4 after CSV removal. Upon completion of backfill and grading, the site was permanently seeded by USFWS.

Health and safety sampling and analysis were performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that action levels were not met or exceeded for the contaminants tested during the Existing (Sanitary Landfills) Remediation Section 1 project.

In May 2005, an ESD entitled "Explanation of Significant Differences for Existing (Sanitary) Landfills Soil Remediation Project" was approved (TTECI 2005b). The ESD documents an increase in HHE and biota soil excavation volumes associated with the landfill sites due to over excavation of required volume to ensure complete removal. The ESD also documents a significant decrease in trash/debris volume. Trash/debris volume was identified in the ROD based on estimated trench depth and lateral extent. Remediation was performed to excavate all visible trash/debris from each identified trench. The reduced volume is based on the differences between ROD-assumed landfill trench depths and lateral extents and actual debris encountered during excavation.

As documented in the Addendum (RVO 2004e), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The addendum to the CCR was approved by EPA on March 30, 2006 for the additional CSV soil excavation. The approval of the Addendum occurred after the March 31, 2005 cutoff date for the 2005 FYR; therefore, this project will also be included in the 2010 FYRR.

4.3.3.9 Existing (Sanitary) Landfills Remediation Section 4 #21

This project addressed remedial actions stated in the On-Post ROD for a distinct portion of the ESL Project. The selected remedy in the ROD for Sanitary Landfills requires the following:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of landfill debris and soil posing a potential risk to biota. The*

consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."

The selected remedy in the On-Post ROD for revegetation is:

"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."

Additionally, the ROD remediation standard that applies to the sanitary landfills is to accomplish the following:

"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the aerial and vertical extent detailed by the soil volume calculations in the administrative record.

Meet air quality and odor standards that are ARARs."

The ROD remediation goals that apply to the project include:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

The overall Section 4 ESL Remediation Project consists of three separate sites identified as WSA-2, WSA-3c and WSA-5. Within these three sites, there were four trash and debris trenches (T/D- 1 through -4) and three HHE areas (HH-1 through 3) in WSA-2; one HHE area (HH-1) in WSA-3c; and fourteen trash and debris trenches (T/D-1 through 14) and two HHE areas (HH-1 and 2) in WSA-5.

The final project design required that the specified volumes be excavated fully as well as excavating visual trash and debris that extended past the specified volumes. During excavation of the first few trenches in WSA-5, it became apparent that the specified volumes were overly conservative, causing excavation of clean soil. As a result, this project was modified to allow exploratory investigative trenches to be excavated at each design-identified trench location to locate the limits of the trench and then excavate the trash and debris wherever encountered. This approach did not modify HHE areas, and resulted in significant reductions in clean/undisturbed soil excavation.

Ultimately the ESL sites in Section 4 yielded 11,408 cy of HHE soil and 40,260 cy of trash and debris. HHE soils were excavated and disposed in the HWL and the trash and debris was disposed Basin A. ACM was encountered during soil excavation and taken to the HWL.

An excavation inspector was utilized to identify potential special wastes such as ACM, drums, PCB-containing equipment/containers, gas cylinders, medical waste, and batteries. A UXO specialist was utilized to identify potential UXO and agent-containing items.

Small fragments of ACM mixed with construction debris were found in many of the excavation areas. Given that there was no cost-effective way to segregate ACM from the construction debris, the material was loaded into lined containers, trucks, or leakproof rolloff containers and disposed at the HWL. All visible ACM was taken to the HWL.

Small bottles were also frequently found during excavations. UXO specialists inspected and screened all bottles from the excavation or the bucket of the excavator. If a bottle was determined to contain liquid, then the bottle was sent to the on-site Environmental Analytical Laboratory for agent screening. None of the bottles encountered during excavation tested positive for agent.

Ten intact drums were encountered and removed from the excavation areas during the project. A trained drum-handling crew removed the drums from the excavation, overpacked the drums, and stored them within a designated staging area in Section 4. Workers wearing Level B PPE, collected samples for agent screening. None of the samples collected tested positive for agent. Weekly inspections were conducted on the drums and drum storage areas. The drums were ultimately disposed offsite at permitted facilities with CERCLA Offsite Rule approval.

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. However, the approved design for ESL Section 4 (WSA-2) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. However, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota. The BAS evaluated WSA-2 and determined, because of its less than 1 acre size, the site did not pose excessive risk to biota (USFWS 2002a).

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the ESL Project, 14 confirmatory samples were taken. Sampling results identified 567 cy of CSV soil, which was excavated and disposed in the HWL. All soils removed were verified by pre- and post-excavation surveys.

All trenches were backfilled. After the remedial excavation and backfilling was completed and survey documentation and inspections approved by the PMC, the RVO and the Regulatory Agencies, the site was finish graded to promote positive drainage and to blend into the surrounding grades. Approximately 1,000 cy of backfill soil was obtained from a soil stockpile generated during construction of the Lake Ladora dam. During subsequent remediation of a TRER area adjacent to the dam, contaminated soil was discovered near the dam. However, the soil stockpile used for backfill soil was generated from the spillway area and dam directly and did not contain contaminated soil from the TRER area.

Upon completion of backfill and grading, the soil was amended. The sites were then permanently seeded by USFWS and mulched by the PMC Subcontractor. The sites were irrigated in 2000 after the surrounding areas were permanently seeded by USFWS.

Health and safety sampling and analysis were performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were met or exceeded for the contaminants tested during the Existing (Sanitary Landfills) Remediation Section 4 project.

In May 2005, an ESD entitled "Explanation of Significant Differences for Existing (Sanitary) Landfills Soil Remediation Project" was approved (TTECI 2005b). The ESD documents an increase in HHE and biota soil excavation volumes associated with the landfill sites due to over excavation of required volume to ensure complete removal. The ESD also documents a significant decrease in trash/debris volume. Trash/debris volume was identified in the ROD based on estimated trench depth and lateral extent. Remediation was performed to excavate all visible trash/debris from each identified trench. The reduced volume is based on the differences between ROD-assumed landfill trench depths and lateral extents and actual debris encountered during excavation.

As documented in the CCR (FWENC 2000f), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on May 25, 2000.

4.3.3.10 Existing (Sanitary) Landfills Remediation Section 36 #22

This project addressed remedial actions stated in the On-Post ROD for a distinct portion of the ESL Project. The selected remedy in the ROD for Sanitary Landfills requires the following:

> "*Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of landfill debris and soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*"

The selected remedy in the On-Post ROD for revegetation is:

> "*Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*"

The Section 36 ESL Remediation included demolition of structures. The RAOs and selected remedy in the On-Post ROD for the structures medium group are presented in Section 4.4.

Additionally, the ROD remediation standard that applies to the sanitary landfills is to accomplish the following:

> "*Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the aerial and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs.*"

The ROD remediation goals that apply to the project include:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

The Section 36 ESL Project is comprised of Site CSA-1d - Sanitary Landfill and Incinerator (included thirteen remedy areas) and Site CSA-2d - Munitions Incinerator Site. Remediation at the two sites involved some or all of the following activities: excavation of trash and debris; excavation of P1, biota, and HHE soils; excavation of munitions debris and associated soil; removal of ACM and related soil/debris, demolition of miscellaneous structures, purging and removing abandoned gas lines, backfilling excavated trenches, final grading and contours, ripping, and revegetation. Remediation waste under the Section 36 ESL Project was transported to the HWL and Basin A.

Disposal of trash and debris, munitions debris and associated soil, P1, biota and HHE soils, ACM and associated soil was documented using a waste tracking system as specified in the RWMP. A total of 3,671 cy of contaminated soil, plus 34 rolloffs containing ACM, were disposed in the HWL during the course of the 36 ESL Project. A total of 78,711 cy was disposed Basin A.

The trash and debris excavated a included such items as ACM, compressed gas cylinders, intact bottles and vials, munitions debris, packing material, and pieces of steel, brick, concrete, and styrofoam. Thirteen compressed gas cylinders were unearthed; their contents were properly vented and then they were disposed in the HWL. Intact bottles and vials were field screened with MINICAMS® by PMC UXO personnel. The intact bottles and vials were then transported to the Environmental Analytical Laboratory for final clearance of the contents of each bottle. There were no confirmed detections of RCWM. All bottles sent to the Environmental Analytical Laboratory were disposed by Environmental Analytical Laboratory as lab waste in the HWL. Munitions debris was segregated from other trash/debris by UXO personnel and disposed at the HWL. No MEC or UXO was found.

In November 2000, an Evaluation Team consisting of staff from the PMC, RVO, USFWS, CDPHE, EPA, and TCHD was formed to evaluate the potential for MEC and RCWM hazards at RMA. There were nine subsurface anomalies identified by the Evaluation Team located within CSA-1d and CSA-2d. As a result of their findings, an RCWM and MEC Hazard Evaluation for Sections 30 and 36 was prepared and incorporated into the design package.

The nine anomaly locations were identified as 1572, 1575, 1577, 1578, 1580, 1582, 1584, 2606, and 2629. Investigation of each anomaly was required by excavating to a predetermined depth and visually inspecting each pothole. The Regulatory Agencies inspected each location to verify the presence or absence of the target anomaly. The Regulatory Agencies decided that anomaly locations 1572, 1575, and 1584 required additional subsurface investigation (DCN-ESL36-14). Investigative trenches were dug at these locations. The trenches and subsurface anomaly investigation yielded no MEC or RCWM.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated.

Accordingly, following excavation of design volumes during the ESL Project, three confirmatory samples were taken and no CSV soil was excavated. All soils removed were verified by pre-and post-excavation surveys.

All trenches were backfilled. After the remedial excavation and backfilling was completed and survey documentation and inspections approved by the PMC, the RVO and Regulatory Agencies, the site was finish graded to promote positive drainage and to blend into the surrounding grades.

CSA-1d and CSA-2d were seeded with an interim vegetation upon completion of remediation activities in Fall 2003.

In May 2005, an ESD entitled "Explanation of Significant Differences for Existing (Sanitary) Landfills Soil Remediation Project" was approved (TTECI 2005b). The ESD documents an increase in HHE and biota soil excavation volumes associated with the landfill sites due to over excavation of required volume to ensure complete removal. The ESD also documents a significant decrease in trash/debris volume. Trash/debris volume was identified in the ROD based on estimated trench depth and lateral extent. Remediation was performed to excavate all visible trash/debris from each identified trench. The reduced volume is based on the differences between ROD-assumed landfill trench depths and lateral extents and actual debris encountered during excavation.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were exceeded requiring PPE upgrade during the ESL Section 36 project.

As documented in the CCR (TTFWI 2004a), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 15, 2004.

4.3.3.11 Lake Sediments Remediation #23

The selected remedy in the On-Post ROD for the Lake Sediments component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation of soil posing risk to biota from Upper Derby Lake to Basin A. The excavated human health exceedance area is backfilled with on-post borrow material and the consolidated material is contained under the Basin A cover. Aquatic sediments are left in place and the area is monitored to ensure that the sediments continue to pose no unacceptable risk to aquatic biota."*

The selected remedy in the On-Post ROD for revegetation is:

"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."

Additionally, the ROD remediation standard that applies to the lake sediments is:

"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the aerial and vertical extent detailed by the soil volume calculations in the administrative record.

Meet air quality and odor standards that are ARARs."

The ROD remediation goals that apply to the project include:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

The Lake Sediments Project is comprised of Upper Derby Lake, Site SSA-1b, and Lower Derby Lake, Site SSA-1c. Remediation at the two sites involved excavation of both HHE and Biota Exceedance Soils, regrading, and surface revegetation. Backfilling was not required as part of the project.

All HHE soil and associated miscellaneous debris were transported to the HWL for disposal, and most biota soil and associated miscellaneous debris were disposed in the Basin A. A small amount of biota soil was disposed in the HWL due to mercury content.

Disposal of HHE, Biota and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. A total of 17,812 cy of HHE soil, 2,372 cy of mercury-contaminated biota soil and associated miscellaneous debris were disposed in the HWL during the course of the project. In addition, 12,671 cy of biota soil and associated debris were disposed Basin A.

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. However, the approved design for Lake Sediments Remediation (SSA-1b) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. However, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

At the recommendation of the BAS, SSA-1b HHE-1 was resampled using an analytical method capable of detecting concentrations of COCs in the biota risk range (USFWS 2002a). Sampling was performed consistent with the method developed by the BAS for the TRER evaluation by collecting a 5-point composite sample over each area representing a small bird exposure range. This additional sampling at Site SSA-1b HHE-1 indicated that there was no contamination remaining that posed excessive risk to biota. For Site SSA-1b HH-2, because of the small size and the future use as an ephemeral wetland the site did not require action.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the ESL Project, eighteen confirmatory samples were taken and 157 cy of CSV soil and associated miscellaneous debris was excavated. All soils removed were verified by pre- and post-excavation surveys.

Areas within the lakes were not revegetated as they were subsequently covered with water. An access road of approximately 2 acres in area was revegetated with locally adapted perennial vegetation.

Health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the Lake Sediments Remediation Project.

The ROD did not require the excavation of HHE sediments in the deep portion of Lower Derby Lake, relying on the presence of water to prevent exposure. Completion of the remedy was approved contingent upon development of institutional controls that would assure no future human contact. This institutional control is discussed at Section 6.3.9.

As documented in the CCR (FWENC 2000g), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project and wastes left in place are subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on April 20, 2000.

4.3.3.12 Burial Trenches Soil Remediation Part I and Part II #24

The selected remedy in the On-Post ROD for the Burial Trenches component of the soil remedy requires:

> "*UXO in these sites is located using a geophysical survey, excavated and transported off-post for detonation (unless the UXO is unstable and must be detonated on-post) or other demilitarization process. Excavation and landfill of human health exceedance soil and backfill with on-post borrow material. Caustic washing and landfill of any agent-contaminated soil found during monitoring. Removal and landfill of munitions debris and nearby soil in excess of TCLP*"

The selected remedy in the On-Post ROD for revegetation is:

> "*Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*"

The ROD remediation standards include:

"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record

Identify, transport off-post, neutralize, and destroy explosives/explosive residue

Ensure excavation of all identified munitions-contaminated soil exceeding TCLP (Munitions Testing and Burial Trenches) and munitions debris and disposal in the on-post RCRA landfill.

Certify 3X level of decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.

Ensure disposal 3X-decontaminated soil and structural debris in the on-post RCRA landfill.

Meet air quality and odor standards that are ARARs."

The ROD remediation goals include:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

Two CCRs have been completed for the Burial Trenches Soil Remediation Project. The Burial Trenches project, Part I CCR, dated September 24, 2002, addressed the thirty-five sites. Eighteen sites were included in the original design and seventeen sites were incorporated into Part I of the Burial Trenches project thereafter using DCNs.

The seventeen sites added to Part I of the Burial Trenches project included:

- The Borrow Area 10 asphalt and surface debris was identified when agent screening was conducted in that area. It became apparent the removal of these obstacles would be necessary in order to begin borrow activities.
- BT32-10 (burn pit site) was added after the design because new aerial photographs dating from 1956 to 1962 became available. The photographs depicted a burn pit that was verified by a visual inspection.
- Sites BT4-01 through BT4-07, BT4-12 and BT4-14 (munitions debris/miscellaneous debris piles) were initially discovered by RVO and the USFWS personnel while completing final revegetation in the subject areas. Sites typically contained metallic remnants of incendiary munitions, miscellaneous soil and areas of charred soil. No UXO was encountered.
- Sites BT4-08 through BT4-11 (disposal pits) were initially discovered by RVO and the USFWS personnel while completing final revegetation in the subject areas. Sites typically contained metallic remnants of incendiary munitions, miscellaneous soil and areas of charred soil. No UXO was encountered.

- Site BT4-13 (miscellaneous surface debris) was initially discovered by RVO and/or USFWS personnel while completing final revegetation in the subject area. The site contained miscellaneous metal and construction debris. No UXO was encountered.
- Site BT9-01 (miscellaneous surface debris) contained slag and other minor debris. No UXO was encountered. The subject debris pile was discovered by the RMA Evaluation Team during a field reconnaissance of the area.

The second Burial Trenches CCR (Part II), dated September 30, 2004, addressed Site ESA-2c and the additional work scope assigned to the project (e.g., characterization and remediation work at Burial Trenches project Sites BT32-11, BT29-01, BT29-02, BT20-01, BT30-01 and BT4-15) as a result of the Evaluation Team (Evaluation Team 2002). Further discussion of the Evaluation Team effort is provided in Section 4.5.1.3.

Remediation at the 42 sites involved some or all of the following activities: surface inspections for MEC and UXO, chemical agent screening, excavation of munitions debris and related soil, removal of HHE soil, removal of ACM and related soil, removal of general construction-related debris (e.g., concrete, wood, rebar, etc.) and trash, backfilling with clean soil material, ripping upon completion of excavations, regrading as required, surface revegetation, and ripping with chemical-agent screening in Borrow Area 10. All HHE soils, munitions debris and related soil, and ACM were transported to and disposed within the HWL. All other material with lesser contamination, (e.g., asphalt pavement, general construction debris and trash, etc.) were transported to and disposed in Basin A. No agent-contaminated soil was identified and for that reason no caustic soil washing was required.

An ESD was provided for formal public comment from May 3, 2004, through June 4, 2004. The ESD indicated that 34 sites were added to the project after the ROD. The ESD described a 42 percent increase in munitions debris/soil volume excavated and a 35 percent decrease in HHE volume excavated. The changes resulted in a 65 percent cost increase (later corrected to 100 percent) to the Burial Trenches project Parts I and II. No comments were received from the public and the ESD was approved by EPA and CDPHE on July 15, 2004 (TTFWI 2004b).

Disposal of all wastestreams, e.g., munitions debris and associated soil, biota soil, ACM, and construction debris and trash, etc., was documented using a waste tracking system as specified in the RWMP. A total of 89,480 cy was excavated by the BT Part I Project and disposed in the HWL or Basin A in accordance with the design. A total of 12,753 cy was excavated by the BT Part II Project and disposed in the HWL or Basin A in accordance with the design.

Approximately 101,000 cy of contaminated soil was disposed in the HWL and 1,000 cy in Basin A during the course of the Burial Trenches project.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the BT projects, 83 confirmatory samples were taken and approximately 12 cy of CSV soil and associated miscellaneous debris was excavated. All soils removed were verified by pre- and post-excavation surveys.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were exceeded, thus requiring no PPE upgrade during the Burial Trenches project.

Nine of the sites (BT29-01, BT29-02, BT 30-01, BT32-01 through BT32-06) have been seeded with interim vegetation. The remainder of the BT sites have been revegetated with locally adapted perennial vegetation.

As documented in the CCRs (FWENC 2002b, TTFWI 2004c), remedial actions under these projects have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. These projects do not require any long-term O&M. The property involved in these projects is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCRs for Part I and Part II on September 25, 2002 and September 30, 2004, respectively.

4.3.3.13 Munitions (Testing) Soil Remediation Part I #25

This project addressed remedial actions stated in the On-Post ROD for the Munitions Testing Soil Remediation project. The selected remedy in the ROD for the Munitions Testing remediation project requires the following:

> *"UXO in these sites is located using a geophysical survey, excavated, and transported offpost for detonation (unless the UXO is unstable and must be detonated on-post) or other demilitarization process. Removal and landfill of munitions debris and nearby soil in excess of TCLP."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

Additionally, the ROD remediation standards that apply to the Munitions Testing remediation project include the following:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
>
> *Ensure excavation of all identified munitions-contaminated soil exceeding TCLP (Munitions Testing and Burial Trenches) and munitions debris and disposal in the on-post RCRA landfill.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

Soil sampling in support of the design demonstrated that soil associated with munitions debris areas passed the TCLP criteria. For that reason, areas containing munitions debris and associated soil, charred soil, slag, or other types of burned debris were excavated on a visual performance basis.

Two CCRs are to be completed for the Munitions Testing project documenting that the subject work has been completed in accordance with the ROD. The Munitions Testing Part I CCR addressed the work scope completed from March through November of 2000 and the subsequent work at CSA-2c that was completed in 2003 (TTECI 2004d). The Munitions Testing Part II CCR will address the additional work scope assigned to the project (e.g., characterization and remediation work at Munitions Testing project Site ESA-4a) as a result of the Evaluation Team efforts (Evaluation Team 2002). In addition, an ESD will be prepared to document a decrease in remediation volumes based upon a comparison of ROD estimated volumes to actual volumes excavated.

The Munitions Testing Part I Project was comprised of Sites CSA-2c, ESA-1a, ESA-1b, ESA-1c, ESA-1d, ESA-4a, ESA-4b and MT29-1. Remediation at these eight sites involved some or all of the following activities: surface inspections for MEC and UXO, excavation of munitions debris and associated soil, removal of ACM and related soil, ripping upon completion of excavations, and surface revegetation. All remediation waste under the Munitions Testing Part I Project was transported to the HWL.

Disposal of munitions debris, associated soil, and ACM generated by the Munitions Testing Part I Project was documented using a waste tracking system as specified in the RWMP. A total of 34,495 cy of munitions debris soil and 613 cy of ACM was disposed in the HWL during the course of this project. A total of 925 cy of Biota soil was disposed Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the Munitions Testing project, five confirmatory samples were taken and no CSV soil was removed

At sites ESA-1a, ESA-1b, ESA-1c, ESA-1d and MT29-1 the soil was amended and permanently seeded by USFWS in the fall of 2001. Site CSA-2c was revegetated with locally adapted perennial vegetation. The eastern half of ESA-4b was soil amended and interim seeded. The western half was left bare due to its continued use for munitions demolition. Sites ESA-4b and ESA-4a will be revegetated after remediation activities are complete.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the Munitions Testing Project.

As documented in the Part I CCR (TTECI 2004d), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 15, 2004.

4.3.3.14 Miscellaneous Northern Tier Soil Remediation #26

The selected remedy in the On-Post ROD for the Surficial Soil component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A or Former Basin F of and soil posing a potential risk to biota from this medium group and excavation and landfill of soil from the pistol and rifle ranges. The consolidated material is contained under the Basin A cover or Basin F cap, and the human health exceedance area is backfilled."*

The selected remedy in the On-Post ROD for the Sand Creek Lateral medium group component of the Miscellaneous Northern Tier Soil Remediation requires:

> *"Excavation and landfill of human health exceedance soil .... The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The Miscellaneous Northern Tier Soil Remediation included demolition of structures. The RAOs and selected remedy in the On-Post ROD for the structures medium group are presented in Section 4.4.

The ROD remediation standards that applied to this project required:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record."*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The Miscellaneous Northern Tier Soil project is comprised of the following three sites: NCSA-8b, Sewage Treatment Plant; NPSA-4, Fuse and Detonator Magazine Ditch; and the Pistol Range. Remediation at the three sites involved excavation of both HHE and Biota soils, demolition of several aboveground and underground structures, backfilling and/or regrading, and surface revegetation.

All HHE soil or debris was transported to the HWL and all Biota soil and debris were disposed Basin A. ACM was discovered at Site NCSA-8b and the Pistol Range House and properly disposed in the HWL. Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. A total of 4,112 cy of contaminated soil was disposed in the HWL and 26,452 cy of biota soil was disposed Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 27 confirmatory samples were taken and approximately 387 cy of CSV soil was excavated. All soils removed were verified by pre- and post-excavation surveys.

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. However, the approved design for Miscellaneous Northern Tier Soils (NCSA-8b) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. However, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

At the recommendation of the BAS, NCSA-8b was resampled using an analytical method capable of detecting concentrations of COCs in the biota risk range (USFWS 2002a). Sampling was performed consistent with the method developed by the BAS for the TRER evaluation by collecting a 5-point composite sample over each area representing a small bird exposure range. This additional sampling indicated that there was contamination remaining at the excavation surface at site NCSA-8b.

As a result, 11,133 cy of CSV soil was excavated from NCSA-8b and taken to the HWL. Initially, 1,500 cy of CSV was disposed in Basin A. Upon further review, the levels of contamination in this CSV soil were determined to require disposal in the HWL. As a result, 4,000 cy were excavated out of Basin A to ensure that all of the 1,500 cy would be removed. The remaining volume of CSV was taken directly to the HWL. This effort was documented in an Addendum to the CCR (RVO 2006a).

Sites NCSA-8b and the Pistol Range were revegetated with locally adapted perennial vegetation. NPSA-4 is within Borrow Area 6 and will be revegetated upon completion of North Plants Soils Remediation Project.

As documented in the CCR (FWENC 2002c) and CCR addendum (RVO 2006a) remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and

Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on April 20, 2000 and the addendum for additional CSV removal was approved March 30, 2006. The approval of the Addendum occurred after the March 31, 2005 cutoff date for the 2005 FYR; therefore, this project will also be included in the 2010 FYRR.

4.3.3.15 Miscellaneous Southern Tier Soil Remediation #27

The selected remedy in the On-Post ROD for the Surficial Soil component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A or Former Basin F of soil posing a potential risk to biota from this medium group and excavation and landfill of soil from the pistol and rifle ranges. The consolidated material is contained under the Basin A cover or Basin F cap and the human health exceedance area is backfilled."*

The selected remedy in the On-Post ROD for the Buried Sediments component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for the Sand Creek Lateral component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for the Ditches/Drainage Areas component of the soil remedy requires:

> *"Excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The Miscellaneous Southern Tier Soil Remediation included demolition of structures. The RAOs and selected remedy in the On-Post ROD for the structures medium group are presented in Section 4.4.

The ROD remediation standards that apply to this project include:

"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record"

Demolish all structural material identified in the ROD for landfilling or consolidation.

Removal of asbestos and ACM to attain TSCA requirements.

Meet air quality and odor standards that are ARARs."

The ROD remediation goals that apply to the project include:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

The project is comprised of the following sites: SSA-2a, South Plants Process Water Ditch System; SSA-2b, Sand Creek Lateral Site; SSA-2c, Overflow Basin ; SSA-3b, Previously Excavated Upper and Lower Derby Lake Sediments; WSA-1f , Isolated Detection; WSA-6a, Motor Pool Ditch; Rifle Range; P1 Soil Site, Fisherman's Parking Lot. Remediation at these eight sites involved excavation of both HHE and Biota Exceedance Soils, demolition of several aboveground structures, backfilling and/or regrading, and surface revegetation.

All HHE Soil or debris was transported to the HWL, and all Biota Exceedance Soil and miscellaneous debris were disposed in Basin A. ACM was discovered at site WSA-6a and the Rifle Range House (Bldg. 863) and properly disposed in the HWL. P1 Soil was excavated at sites SSA-2a and the Fisherman's Parking Lot and subsequently used as backfill at site SSA-3b. The P1 Soil was not used in the upper 2 ft. of backfill.

Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. A total of 36,057 cy of contaminated soil was disposed in the HWL during the course of this project, 23,742 cy of Biota Soil was disposed in the Basin A.

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. However, approved designs for Miscellaneous Southern Tier Soils (SSA-2a, SSA-2b and WSA-6a) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. However, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

The BAS evaluated SSA-2a, SSA-2b and WSA-6a. For Site SSA-2a, the BAS determined the site was small enough (0.1 acre) that it did not present excessive risk to biota. For Sites SSA-2b and WSA-6a, the BAS evaluation revealed that the regrading (i.e., sloping the banks inward) conducted at the close of remediation, affected a greater than 1-ft. backfill at these sites. The

BAS determined (USFWS 2002a) that the regrading and the small area of the sites resulted in acceptable risks to biota and no further action was required.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 82 confirmatory samples were taken and 5,173 cy of CSV soil was excavated. All soils removed were verified by pre- and post-excavation surveys.

All sites, with the exception of WSA-1f, were revegetated with locally adapted perennial vegetation. WSA-1f was interim seeded by a PMC Subcontractor at the completion of remediation.

Subsequent to completion of the project, in an effort to ensure protectiveness, evaluation of isolated detections of contaminants located at greater depths was performed. This effort identified soils exceeding acute Site Evaluation Criteria that, in the absence of additional institutional controls, warranted remediation. A total of 7,819 cy of CSV were excavated and disposed in the HWL. This activity was documented in an addendum to the CCR (RVO 2006b) that was approved by the EPA on March 30, 2006.

In addition, efforts in 2004 related to characterization of Terrestrial Ecological Risks led to discovery of contaminated soils associated with historic operation of the Sand Creek Lateral. Based upon review of aerial photos, it appears that in the 1950s the Army dredged the Sand Creek Lateral and placed the spoils on the southwest or west bank. Subsequently, parts of the Sand Creek Lateral became recontaminated because the spoils and the bank of Sand Creek Lateral were used as backfill. These spoils contained concentrations of aldrin and dieldrin at HHE and Biota levels, warranting additional characterization and remediation.

Although outside the review period of this FYRR, analytical results from sampling along the Sand Creek Lateral show contamination was present along the banks of the Sand Creek Lateral in both Section 2 and Section 35. Complete sampling results are included in the Data Summary Report for Sand Creek Lateral Soils Remediation Project (TTECI 2006e). Due to the discovery of contamination along the banks of the Sand Creek Lateral, a review of other ditches was performed to determine whether similar conditions were evident. Aerial photographs were reviewed to look for evidence of dredging or other activities that might have resulted in additional areas of contamination. Several ditches from the original Miscellaneous Southern Tier Soil Project, comprising South Lakes Ditch site SSA-2a, were identified as potential candidates. Sampling conducted along the banks of these ditches resulted in delineation of two additional areas of biota soil. Excavation of the contamination along the Sand Creek Lateral has been completed and excavation along SSA-2a is pending. The portions of this work associated with the Miscellaneous Southern Tier Soil Project will be documented in a CCR and discussed in the 2010 FYRR.

As documented in the CCR (FWENC 2000h) and CCR addendum (RVO 2006b), with the exception of the Sand Creek Lateral Site SSA-2b and South Plant Ditch site SSA-2a, remedial actions under the Miscellaneous Southern Tier Soil project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. The completion of the Sand Creek Lateral Site SSA-2b and South Plants Ditch Site SSA-2a will be documented in a separate CCR. The project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 14, 2000 and the addendum for the deep acute soil removal on March 30, 2006. The approval of the Addendum occurred after the March 31, 2005 cutoff date for the 2005 FYR; therefore, this project will also be included in the 2010 FYRR.

4.3.3.16 Buried M-1 Pits Soil Remediation #31

The selected remedy in the On-Post ROD for the Buried M-1 Pits component of the soil remedy requires:

> *"Approximately 26,000 BCY of principal threat and human health exceedance soil is treated by solidification/stabilization and then landfilled. The mixture of solidification/stabilization agents will be determined during remedial design by treatability testing. This treatability testing will be used to verify the effectiveness of the treatment process and establish operating parameters for the design of the full-scale operation. Excavation is conducted using vapor- and odor-suppression measures. Caustic washing and landfill of any agent-contaminated soil found during monitoring. The excavated area is backfilled with clean borrow."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standards that apply to the project include:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Landfill all solidified/stabilized material in the on-post RCRA landfill.*
>
> *Provide adequate unconfined compressive strength after solidification/stabilization to meet disposal facility requirements.*
>
> *Certify 3X decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.*
>
> *Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Design treatability testing to achieve a 90 percent reduction in contaminant concentrations in leachate.*
>
> *Design to reduce contaminant concentrations in leachate; a 90 to 99% reduction in contaminant concentrations in leachate is a general guidance and may be varied within a*

reasonable range considering the effectiveness of the technology and the cleanup goals for the site.

**Note: The Treatability Study confirmed that the technology was effective in achieving 90 percent reduction for arsenic. While the treatment was effective for reducing the mercury leachability, the 90 percent reduction Treatability Study goal was not achieved for low mercury feed concentrations. Treatability Study results indicated that final mercury leachate concentrations were below the TCLP regulatory level. Site cleanup goals will be achieved through this technology, therefore the reduction in mercury leachate is considered acceptable.*

Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

There are three individual buried M-1 Pits referred to as P1 (western pit), P2 (central pit), and P3 (eastern pit). Remediation at the M-1 Pits site involved the following activities:

- Conducted excavation using vapor and odor-suppression measures, as required.
- Performed TCLP tests on batches of 4:1 surrounding soil to pit soil that resulted in designating 6 percent cement for full-scale production.
- Treated approximately 26,000 cy of principal threat and HHE material by solidification/stabilization, then haul and dispose in the HWL.
- Performed chemical agent screening (ROD 3X) during excavation of pit soil with no detections. For that reason no caustic washing of soil was required.
- Backfilled the excavated area to existing grade and contours with Borrow Area 3 soil.

Disposal of 27,465 cy of contaminated soil and 450 cy of concrete debris in the HWL was documented using a waste tracking system as specified in the RWMP.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 9 confirmatory samples were taken and no CSV soil was excavated. All soils removed were verified by pre- and post-excavation surveys.

Final revegetation at this project site will be accomplished as part of cover construction.

Although frequent strong odors were measured on-site during project implementation, odors were detected by citizens off-site on September 13, 2001, and odors were sufficiently strong that several personnel on-site chose to depart RMA, routine odor monitoring by the PMC did not detect odors at the fenceline at or exceeding RMA odor action levels during work execution. Off-site transport of fugitive dust was not observed. Ambient air monitoring conducted during the project indicated no exceedances of on-post or fenceline acute and chronic criteria.

A visible thin haze formed on several days during the course of the M-1 Pits Project, including August 23, September 13, 20, 24, 28, and October 8, 2001. Of the haze events, the one on September 13, 2001 was the most distinct and accompanied by the highest level of odor at the project site. The odors moved slowly off-site as morning winds began to develop. A contingency grab sample for volatile organic compounds (VOCs) collected near the project contamination control line on September 13 showed only two chemicals had elevated concentrations, bicycloheptadiene and dicyclopentadiene, but they were both below threshold limit values and acute-risk criteria. Enhanced ambient air monitoring performed on September 20th, 24th, and 28th showed similar results. Citizens reported detecting strong odors and a visible haze beyond the fenceline in the early morning hours of September 13 at approximately 6:30 a.m.-7:30 a.m. The PMC personnel who performed odor monitoring around 8:00 a.m. did not detect fenceline odors at or exceeding RMA odor action levels. The project was shut down by 8:30 a.m. in response to excessive on-site odors but later restarted when dispersion conditions improved. The PMC performed odor monitoring four additional times on September 13, recording only slight odor during mid-afternoon at the fenceline. In presentations to citizen advisory groups following the incident, the RVO indicated that the blue haze was related to the M-1 Pits remedial activities. Chemists from Shell Oil Company, the manufacturer of dicyclopentadiene and bicycloheptadiene, suggested that the blue haze may have been produced by adsorption of water molecules to cyclodienes. The blue haze has not been observed since M-1 project completion.

As a result of the September 13 event, a protocol was initiated on September 19 to delay daily startup of project activities until meteorological conditions allowed favorable dispersion. Initially, a stability category of C was required for startup. Based on the first two weeks of experience, the required stability category was changed to a less stringent D on October 5. Air group personnel notified project personnel once conditions were acceptable. In addition, beginning September 19 and lasting nine and one-half working days, daily site activities were limited to two major operations, down from four. For example, either excavation and mixing or processing and hauling occurred. In addition, no processed material was allowed to be stockpiled overnight. All processed material had to be placed in the HWL by the end of the workday. Once these changes were made, the occurrence of strong odors beyond the project contamination control line decreased.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. Results indicated that no action levels within the work area were exceeded that required PPE upgrade, since the highest level of respiratory protection was used during the M-1 Pits Remediation Project. Supplemental real-time air monitoring data collected by the PMC Air Monitoring Group at the project contamination control line, indicated that instantaneous concentrations reached the OSHA ceiling limit for mercury on nine occasions. No workers were present or working at the location of those detections. As a result of those detections and other monitoring performed by the Subcontractor, the Subcontractor expanded the exclusion zone to ensure that unprotected workers were not exposed.

On November 7, 2001, a joint Lessons Learned was held with the PMC, RVO, EPA, CDPHE, and TCHD. This was an all-day session to discuss major issues that arose during the course of the project and to propose solutions for future projects. One of the primary issues identified was that although emission sources were characterized to the extent practical prior to remediation, unexpected field conditions were encountered. In future designs, mechanisms to respond to such conditions should be included in the project plans.

The Buried M-1 Pits Soil Remediation Project requires no caps, covers or treatment facilities; however the M-1 Pits are located within the South Plants Central Processing Area and will therefore be covered beneath the Central Processing Area soil cover. No long-term O&M are required at this time because the South Plants soil covers have yet to be completed. Long-term O&M requirements will be discussed in the Phase 2, Part 3 CCR that will document final construction of the 3.25-ft. and 4.5-ft. South Plants soil covers.

As documented in the CCR (FWENC 2002d), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 18, 2002.

4.3.3.17 Hex Pit Soil Remediation #32

This project addressed remedial actions stated in the On-Post ROD for the Hex Pit Soil Remediation project. The selected remedy in the ROD for the project requires the following:

> *"Treatment of approximately 1,000 BCY of principal threat material using an innovative thermal technology. The remaining 2,300 BCY are excavated and disposed in the on-post hazardous waste landfill. Remediation activities are conducted using vapor-and odor-suppression measures as required. Treatability testing will be performed during remedial design to verify the effectiveness of the innovative thermal process and establish operating parameters for the design of the full-scale operation. The innovative thermal technology must meet the treatability study technology evaluation criteria described in the dispute resolution agreement...Solidification/stabilization will become the selected remedy if all evaluation criteria for the innovative thermal technology are not met. Treatability testing for solidification will be performed to verify the effectiveness of the solidification process and determine appropriate solidification/stabilization agents. Treatability testing and technology evaluation will be conducted in accordance with EPA guidance..."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standards that apply to the project include:

> *"Design to achieve 90% or greater destruction of contaminants.*
>
> *Landfill all treatment residuals and untreated material in the on-post hazardous waste landfill.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

As noted above, the ROD designated the Hex Pit site to be remediated by use of an innovative thermal treatment technology. The original project tasks are listed below:

- Treat approximately 2,550 cy of principal threat and HHE material and soil using an innovative thermal technology.
- Conduct remediation activities using vapor and odor-suppression measures as required.

In accordance with the ROD and subsequent Innovative Thermal Technology Evaluation Report (Hex Pit Working Group 1998), In Situ Thermal Destruction was the innovative technology chosen to remediate the site. In 1999, a bench-scale treatability test of the In Situ Thermal Destruction technology was performed on contaminated soil samples collected from the Hex Pit (ENSR 2000). The bench-scale test results indicated that In Situ Thermal Destruction was capable of achieving destruction/removal efficiencies in excess of 99 percent for all COCs. The bench-scale test also concluded that In Situ Thermal Destruction had the potential to reduce the mass of dioxins and furans at the site by greater than 90 percent. Evaluation of the offgas from the bench testing indicated that the full-scale remediation would require an air pollution control system to address emissions of organic compounds and acid gases.

The In Situ Thermal Destruction entailed heating the contaminated soil above the boiling point of the COCs, using a network of heater wells. Approximately one quarter of the heater wells were configured as heater-vacuum wells to allow collection of the volatilized contaminants. The thermal well field was designed to achieve a minimum interwell temperature of 325°C (617°F) within the delineated boundary of the Hex Pit. Contaminants lying within the hottest zone or contaminants that are drawn through the hot zone around the heater wells are typically oxidized or pyrolized in place. Thus, the majority of the contaminant mass destruction would occur in situ. Vapors extracted from the subsurface would be treated aboveground through a trailer-mounted offgas treatment system to comply with permitted emission limits.

The final design included the installation of 210 heater wells and 56 heater-vacuum wells in a triangular grid pattern over the site. All thermal wells were spaced on 6-ft. centers. Temperature and pressure monitoring devices were installed within the limits of the well field at various depths.

Construction of the In Situ Thermal Destruction system started in October 2001 and field implementation of the treatment process began in March 2002. The remediation began by heating the heater-vacuum wells only, and then starting the heater wells in phases. As the soil and waste became heated, the hexachlorocyclopentadiene began to decompose, resulting in the release of chlorine. When mixed with heated water vapor from the surrounding soil, hydrochloric acid vapor was formed. The In Situ Thermal Destruction design anticipated that the hydrochloric acid formed would be neutralized, to a large extent, by the higher pH of the surrounding soil; however, this did not occur. As a result, the hydrochloric acid vapor was drawn into the vacuum wells, piping, and process equipment. This vapor, as it condensed, began to corrode the piping, well casings and other process equipment, which caused a failure of some of the In Situ Thermal Destruction process equipment and forced a shutdown of the system after two weeks of operation. At this stage only about one third of the heater wells had been activated in the southern portion of the site.

Assessment of the system indicated that the corrosion rate of the hydrochloric acid for the system materials was greater than anticipated during design, resulting in the failure. To continue the In Situ Thermal Destruction remedy would have required replacement of all well casings, piping and process equipment with a more costly material that could resist hydrochloric acid corrosion, and require a bench-scale test to confirm that the new material would work. This would not only increase costs for the Hex Pit project, but also delay the South Plants project, further increasing costs. Consequently, In Situ Thermal Destruction was eliminated as the remedial action for the Hex Pit site. This set into action the process for a ROD Amendment in order to remediate the site in a different manner than indicated in the 1996 ROD.

Although the original remedy provided solidification/stabilization as a contingent remedy, the ROD amendment noted that the tarry nature of the material would create material handling difficulties. In addition, the ROD amendment noted concerns as to the availability of solidification/stabilization reagents that would reduce the mobility of the Hex Pit material due to the high concentrations of organic COCs. The ROD amendment was offered for public comment from September 22, 2002 through November 22, 2002 and the alternative remedy for this project was approved by the ROD Amendment on April 15, 2003 (FWENC 2003c). The selected remedy documented in the ROD Amendment requires:

> *"...excavation of contaminated soil and waste material from the Hex Pit with disposal in the on-site HWL. Air emissions and odor controls, developed during remedial design to meet regulatory requirements, will be applied during excavation, transportation and placement of waste in the HWL. Excavation will be completed to a minimum depth of 10 feet."*

The ROD remediation standard documented in the ROD amendment that applies to the project became the following:

> *"Excavate all contaminated soil identified in the ROD Amendment for landfilling in the RMA HWL to the areal and vertical extent identified in the ROD Amendment. Visually identified Hex material located beyond the design boundary will be excavated for landfilling in the RMA HWL."*

After abandonment of the In Situ Thermal Destruction process, the site was covered with approximately 3.5 ft. of P1 soil and sloped to drain to the north end of the site to match surrounding soil drainage. Subsequent soil samples indicated the pH of the soil was affected by the short duration of the In Situ Thermal Destruction heating process and pH varied from 1.97 to 9.97 across the site.

Remediation at the Hex Pit site involved excavation of principal threat and HHE material/soil, removal of P1 cover soil, removal of In Situ Thermal Destruction well casings and blankets, abandoning three horizontal dewatering wells, backfilling and surface regrading. All principal threat/HHE and P1 soil or debris was transported to the on-site HWL.

Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. A total of 4,231 cy of contaminated principal threat and P1 soil and 79 cy of miscellaneous debris was disposed in the HWL during the course of this project.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, no confirmatory samples were taken for this project since the performance criteria was visually based and the Subcontractor overexcavated and removed all stained soil that was noted by the Regulatory Agencies. All soils removed were verified by pre- and post-excavation surveys.

Final revegetation of this site will be accomplished as part of cover construction.

The Health and Safety monitoring results indicated no action levels were exceeded requiring PPE upgrade during the Hex Pit remediation. The results of the integrated air monitoring and real-time data indicated that there were no exposures over the Occupational Safety and Health Administration permissible levels.

The Hex Pit Soil Remediation Project requires no caps, covers or treatment facilities and therefore no long-term O&M are required at this time because the South Plants soil covers have yet to be completed. Long-term O&M requirements will be discussed in the Phase 2, Part 3 CCR that will document final construction of the 3.25-ft. and 4.5-ft. South Plants soil covers.

As documented in the CCR (TTFWI 2004e), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 21, 2004.

4.3.3.18 South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 1 #33

The selected remedy in the On-Post ROD for the South Plants Central Processing Area component of the soil remedy requires:

> *"Excavation and landfill of principal threat and human health exceedance soil to a depth of 5 ft and caustic washing and landfill of any agent-contaminated soil found during monitoring. Backfill excavation and placement of a soil cover consisting of a 1-ft-thick biota barrier and a 4-ft-thick soil/vegetation layer over the entire site to contain the remaining human health exceedance soil and soil posing a potential risk to biota. Soil posing a potential risk to biota from other portions of South Plants may be used as backfill and/or gradefill prior to placement of the soil cover."*

The selected remedy in the On-Post ROD for the South Plants Balance of Areas component or the soil remedy requires:

> *"Excavation (maximum depth of 10 ft) and landfill of principal threat and human health exceedance soil and caustic washing and landfill of any agent-contaminated soil found during monitoring. Any UXO encountered will be excavated and transported offpost for detonation (unless the UXO is unstable and must be detonated onpost) or other demilitarization process. Excavation of soil posing a potential risk to biota and consolidation as backfill and/or gradefill under the South Plants Central Processing Area soil cover and/or for use as backfill for excavated areas within this medium group. The former human health exceedance area is covered with a 3-ft.-thick soil cover and the former potential risk to biota area is covered with a 1-ft.-thick soil cover. Prior to placing this cover, two composite samples per acre will be collected to verify that the soil under the 1-ft.-thick cover does not exceed the human health or principal threat criteria. If the residual soil is found to exceed these levels, the 3-ft.-thick cover will be extended over these areas or the exceedance soil will be excavated and landfilled. The top 1 ft. of the entire soil cover area will be constructed using soil from on-post borrow areas."*

The selected remedy in the On-Post ROD for the South Plant Ditches component of the soil remedy requires:

> *"Excavation and landfill of principal threat and human health exceedance soil. Excavation of soil posing a potential risk to biota and consolidation under the South Plants Central Processing Area soil cover. Backfill excavated area with on-post borrow material. These sites are contained under the South Plants Balance of Areas soil cover."*

The selected remedy in the On-Post ROD for the Chemical Sewers component of the soil remedy requires:

> *"For sewers located within the South Plants Central Processing Area...the sewer void space is plugged with a concrete mixture to prohibit access to these lines and eliminate them as a potential migration pathway for contaminated groundwater. The plugged sewers are contained beneath the soil cover or cap in their respective sites. For sewers located outside the South Plants Central Procession Area...sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced."*

The selected remedy in the On-Post ROD for the PCB-contaminated soil component of the remedy requires:

> *"Excavation and disposal in the on-post TSCA-compliant landfill of PCB-contaminated soil (three areas identified by the PCB IRA with concentrations of 250 ppm or greater)."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standards that apply to the projects include the following:

> *"Certify 3X decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.*
>
> *Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.*
>
> *Identify, transport offpost, neutralize, and destroy explosives/explosive residue.*
>
> *Ensure excavation of all identified...munitions debris and disposal in the on-post RCRA landfill.*
>
> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Removal of contamination >250 ppm in the three areas identified by the PCB IRA and disposal in the on-post TSCA-compliant landfill.*
>
> *If necessary, any suspected PCB soil contamination areas will be characterized further during remedial design. If additional PCB-contaminated soil is found with concentrations of 50 ppm or greater, the Army will determine any necessary remedial action in consultation with the EPA.*
>
> *Remove structural materials with PCB concentrations of 50 ppm or greater that exist above ground level, as well as contaminated parts of floor slabs and foundations identified for removal, and dispose in the on-post TSCA-compliant landfill.*
>
> *PCB-contaminated sections of floor slabs or foundations that are not identified for removal, and that have PCB concentrations of less than 50 ppm, will be left in place.*
>
> *Interrupt exposure pathway by permanently plugging all Sanitary Sewer manholes.*
>
> *Interrupt exposure pathway by permanently plugging all chemical sewer lines and manholes not excavated.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The South Plants Balance of Areas and Central Processing Area Soil Remediation Project was separated into two phases during design. At the close of the FYR period, Phase 1 was complete and Phase 2 was under construction and is described in Section 4.3.1.4.

The South Plants Balance of Areas and Central Processing Area Phase 1 was comprised of 30 ROD-defined Sites. Remediation throughout the sites involved the following activities: excavation of HHE soil and areas of Biota soil, excavation of PCB-contaminated soil and petroleum-contaminated soil, chemical sewer excavation, chemical agent materiel screening, well abandonment, ACM abatement, underground storage tank removal, foundation removal, backfilling/grading and placement of interim revegetation. HHE soil and debris was transported to the HWL for disposal. Excavated Biota soil was used as backfill in excavations beneath the 3.25-ft South Plants Balance of Areas cover and 4.5-ft South Plants Central Processing Area cover areas or disposed in the HWL. Clean soil was used as backfill in excavated areas of Biota Exceedance soil in the 1-ft backfill area. The above-grade portion of trees located in the remediation areas was disposed in the Basin A.

An ESD (FWENC 2000a) was prepared for the South Plants Balance of Areas and Central Processing Area, and approved during South Plants Soils Phase 1, and is applicable to both South Plants Soils Phase 1 and Phase 2. The ESD was approved by the Regulatory Agencies on November 10, 2000, following completion of the April 6 through May 8, 2000 public review and comment period, from which no comments were received. The ESD documents and provides rationale for changes to the remedy for this project as described in the ROD. The changes to the South Plants remedy documented in the ESD are as follows:

- Removal of the requirement for a 1-ft. cover in the South Plants Balance of Areas in lieu of 1 ft. of backfill.
- Enhancement of construction standards for the 4.5-ft. South Plants Central Processing Area cover.
- Removal of the requirement to excavate Biota Soil from under the 3.25-ft. cover area of the South Plants Balance of Areas.

As described in the ESD, an enhanced sampling program was conducted that included collection of 200 samples in addition to the ROD-required 2 samples per acre for a total of more than 600 samples over 208 acres. The ESD also required removal of all identified HHE soil and removal of all Biota soil in the 1-ft. backfill area.

Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. During Phase 1, 304,689 cy of contaminated soil was disposed in the HWL, approximately 39,181 cy of Biota Exceedance Soil was used as gradefill beneath the future South Plants Covers, and approximately 689 cy of miscellaneous debris was disposed in the Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 232 Confirmatory Soil Samples were collected during this project, and 25,215 cy of CSV soil was excavated based on the sample results and visual observation. Excavated CSV soil was disposed in the HWL. All soils removed were verified by pre- and post-excavation surveys.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were exceeded requiring PPE upgrade during the project.

The project sites received temporary vegetation to control erosion.

The South Plants Balance of Areas and Central Processing Area Phase 1 project requires no caps, covers or treatment facilities, therefore no long-term O&M are required at this time since the South Plants soil covers have yet to be completed. Long-term O&M requirements will be discussed in the Phase 2, Part 3 CCR that will document final construction of the 3.25-ft. and 4.5-ft. South Plants soil covers.

As documented in the CCR (FWENC 2002e), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This soil remediation phase of the project does not require any long-term O&M. The property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on September 24, 2002.

4.3.3.19 Secondary Basins Soil Remediation Phase I and II #37

The selected remedy in the ROD for the Secondary Basins Soil Remediation Phase I and II requires:

> *"Excavation and landfill of human health exceedance soil. The excavated areas is backfilled with on-post borrow material. A 2-ft-thick soil cover is placed over the entire area of Basins B, C, and D, including the potential biota risk area."*

The selected remedy in the ROD for Surficial Soils requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A or Former Basin F of soil posing a potential risk to biota from this medium group and excavation .... The consolidated material is contained under the Basin A cover or Basin F cap, and the human health exceedance area is backfilled."*

The selected remedy in the On-Post ROD for the Sand Creek Lateral medium group component of the Secondary Basins Soil Remediation requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standards that apply to the project include:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The Secondary Basins Soil Remediation Project is comprised of the following seven sites: Basin C (NCSA-2a), Basin D (NCSA-2b), Basin B Drainage Ditches (NCSA-2d), Basin F Exterior Biota Surficial Soil (NCSA-4b), HHE Surficial Soil, Section 26 Biota Surficial Soil and P1 Surficial Soil.

Remediation at the sites during Part 1 of the project included the following:

- Removal of HHE soil, concrete debris, and an 18-inch-diameter steel pipe and disposal in the on-site HWL
- Removal of concrete erosion blocks and pump structure from Biota soil areas and disposal Basin A
- Construction of a two-way haul road
- Removal of Biota soil from beneath Subcontractor haul road and disposal Basin A

Remediation at the sites during Part 2 of the project included the following:

- Removal of Biota and P1 soils and associated debris and disposal in Basin A
- Removal of two concrete headwalls and a spillway and disposal in Basin A

Additional work items were added to the Secondary Basins Remediation Project in Part 2. These included the removal of P1 soils in Borrow Area 3 north and the removal of a USFWS debris pile located in Section 35.

An ESD was prepared for Secondary Basins B, C and D (FWENC 2002f). The ESD documented two significant changes to the Secondary Basins remedy. First, it changed the requirement for biota soil from containment in place under a 2-ft.-thick soil cover to excavation and consolidation in Basin A. Second, it deleted the requirement for the 2-ft.-thick soil cover for Secondary Basins sites and replaced it with 1 ft. of backfill. The change to include biota soil excavation resulted in an increase of 125,542 cy over the ROD volume for biota soil excavation and consolidation to Basin A. It eliminated the 2-ft.-thick soil cover requirement and the associated long-term O&M.

One of the key elements of the modified remedy was to ensure that no HHE soil would remain in the Basins following remediation. As a result, a soil sampling program was conducted that included 224 samples at various depths throughout the three Basins to ensure that the resultant soil surface following excavation would not contain concentrations of COCs greater than the human health Site Evaluation Criteria defined in the ROD. The sampling program was also undertaken to document the absence of HHE at greater depth. The results indicated that there were no samples exceeding the human health Site Evaluation Criteria.

The ESD was made available for public review and comment and a presentation was made to the Restoration Advisory Board on December 13, 2001. The public comment period closed on January 14, 2002, and the ESD was approved by the EPA on February 7, 2002, and by the CDPHE on February 13, 2002.

Basins C and D, located in Section 26, were remediated under the Secondary Basins Soil Remediation Project. Basin B is located in Section 35 and was remediated under the Section 35 Soil Remediation Project.

Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. A total of 47,884 cy of HHE soil and 1,047 cy of CSV were disposed in the on-site HWL during Part 1 of this project. Approximately 440 cy of Biota soil were disposed Basin A during Part 1. A total of 160,225 cy of Biota soil and 23,558 cy of P1 soil were disposed Basin A during Part 2 of the project. A total of 15 cy of CSV soil were disposed at the on-site HWL during Part 2 of this project.

A total of 39 Confirmatory Soil Samples were collected during Part 1 of this project, and 1,047 cy of CSV soil were excavated based on the sample results. There were no Confirmatory Soil Samples collected during Part 2 of the project. However, a concrete basin and associated tile pipe discovered in the north part of the Basin F Exterior Biota Surficial Soil site (NCSA-4b) were removed as CSV and recorded on a CSV Tracking Form. A total of 15 cy of debris and soil were removed and disposed in the on-site HWL. After completion of Part 2 of the project, one additional Confirmatory Soil Sample was collected from NCSA-2a at the direction of the Regulatory Agencies to verify the existence of COC concentrations exceeding the acute human health Site Evaluation Criteria at depths greater than 1 ft. The sample analyses came back as nondetect and, therefore, no additional CSV was excavated.

Sites NCSA-2a, NCSA-2b, NCSA-4b and NCSA-2d and Secondary Basins Surficial Soil have been revegetated with locally adapted perennial vegetation.

Personal health and safety sampling and analysis were performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that there were no action levels requiring PPE upgrade during the Secondary Basins Soil Remediation Project based on the Health and Safety Plan.

As documented in the CCR (TTFWI 2004f), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 15, 2004.

4.3.3.20 Section 35 Soil Remediation #41

The selected remedy in the On-Post ROD for Surficial Soils component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and excavations and consolidation to Basin A…of soil posing a potential risk to biota from this medium*

group.... The consolidated material is contained under the Basin A cover..., and the human health exceedance area is backfilled."

The selected remedy in the On-Post ROD for the Chemical Sewers component of the soil remedy requires:

> *"For sewers located outside the South Plants Central Processing Area and Complex Trenches areas, sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced."*

The selected remedy in the On-Post ROD for the Ditches/Drainage Areas component of the soil remedy requires:

> *"Excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for the Sand Creek Lateral component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material."*

The selected remedy in the On-Post ROD for the Secondary Basins component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil. The excavated areas is backfilled with on-post borrow material. A 2-ft-thick soil cover is placed over the entire area of Basins B, C, and D, including the potential biota risk area."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standards that apply to the projects include the following:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Interrupt exposure pathway by permanently plugging all Sanitary Sewer manholes.*
>
> *Interrupt exposure pathway by permanently plugging all chemical sewer lines and manholes not excavated.*
>
> *Meet air quality and odor standards that are ARARs."*

The ROD remediation goals that apply to the project include:

> *"Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."*

The Section 35 Soil Remediation project is comprised of the following eight sites: Basin B Drainage Ditch NCSA-1c), Basin B Drainage Ditch (NCSA-5b), Secondary Basin B (NCSA-5a), Sand Creek Lateral (NCSA-5c), South Plants Stormwater Drainage Ditch (NCSA-5d), Chemical Sewer Site (NCSA-6a), Section 35 Surficial Soil Site and Section 35 P1 Soil Sites that are not in borrow areas.

Remediation at the sites involved excavation of HHE Soils, Biota Risk Soils, P1 Soils, chemical sewers, associated culverts, miscellaneous debris, backfilling, regrading, and surface revegetation. All HHE soil, chemical sewers, and associated debris were transported to the on-site HWL. All Biota Risk Soil, P1 soil and associated miscellaneous debris were disposed Basin A.

Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. A total of 16,854 cy of HHE and CSV were disposed in the HWL during the course of this project, and 88,701 cy of Biota Soil were disposed in Basin A. An additional 500 cy of Biota Soil, excavated with underlying CSV, was disposed in the HWL per Agency direction, for a total of 89,201 cy of Biota Soil excavated and disposed. A total of 36,781 cy of P1 soil was also disposed in Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 37 confirmatory samples were taken and a total of 5,059 cy of CSV soil was excavated and taken to the HWL. All soils removed were verified by pre- and post-excavation surveys.

Section 35 sites were revegetated with locally adapted perennial vegetation. Remaining sites will be seeded following remediation of the Sand Creek Lateral sites.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the Section 35 Soil Remediation Project.

Two ESDs affected the Section 35 Soil Remediation Project. The first was in regard to the former Chemical Sewer Site (NCSA-6a). The primary change documented in that ESD was to eliminate the ROD-required soil removal for site NCSA-6a in Sections 35 and 26 (FWENC 2000i). During the design review process for the excavation of soil beneath and adjacent to the chemical sewers identified in the On-Post ROD, it was discovered that soil associated with chemical sewer site NCSA-6a located in section 35 and 26 had been removed during the 1982 sewer removal project. To ensure all the contaminated soil had been removed in the area, additional soil sampling was conducted in April 2000. The analytical results showed no evidence of contaminated soil remaining that required excavation, thus eliminating the need for further soil excavation.

The second ESD was prepared for Secondary Basins B, C and D. Secondary Basin B (NCSA-5a) is located in Section 35. The requirement for containment of biota soil in place and a 2-ft. soil cover over the basins was changed to excavation of the biota soil followed by placement of 1 ft. of backfill (FWENC 2002f).

In addition, efforts in 2004 related to characterization of Terrestrial Ecological Risks led to discovery of contaminated soils associated with historic operation of the Sand Creek Lateral. Based upon review of aerial photos, it appears that in the 1950s the Army dredged the Sand Creek Lateral and placed the spoils on the southwest or west bank. Subsequently, parts of the Sand Creek Lateral became recontaminated because the spoils and the bank of Sand Creek Lateral were used as backfill. These spoils contain concentrations of aldrin and dieldrin at HHE and Biota levels, warranting additional characterization and remediation.

Although outside the review period of this FYRR, analytical results from sampling along the Sand Creek Lateral show contamination was present along the banks of the Sand Creek Lateral in both Section 2 and Section 35. Complete sampling results are included in the Data Summary Report for Sand Creek Lateral Soils Remediation Project (TTECI 2006e). Due to the discovery of contamination along the banks of the Sand Creek Lateral, a review of other ditches was performed to determine whether similar conditions were evident. Aerial photographs were reviewed to look for evidence of dredging or other activities that might have resulted in additional areas of contamination. Several ditches from the original Section 35 Soil Remediation Project, comprising ditch site NCSA-5b, were identified as potential candidates. Sampling conducted along the banks of these ditches resulted in delineation of two additional areas of HHE soil. Excavation of the contamination along the Sand Creek Lateral and NCSA-5b has been completed. The portions of this work associated with the Section 35 Soil Remediation Project will be documented in a CCR and discussed in the 2010 FYRR.

As documented in the CCR (FWENC 2003d), with the exception of the Sand Creek Lateral (NCSA-5c), remedial actions under the Section 35 Soil Remediation project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. The completion of the Sand Creek Lateral (NCSA-5c) will be documented in a separate CCR. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 15, 2004.

4.4 On-Post Structures Remedy Selection and Implementation

The RAOs from the On-Post ROD for the structures medium include:

Human Health

- *Prevent contact with the physical hazards and contaminant exposure associated with structures.*
- *Limit inhalation of asbestos fibers to applicable regulatory standards.*

- *Limit releases or migration of COCs from structures to soil or water in excess of remediation goals for those media or to air in excess of risk-based criteria for inhalation as developed in the HHRC.*

<u>Ecological Protection</u>

- *Prevent contact with the physical hazards associated with structures.*
- *Prevent biota from entering structures that are potentially contaminated."*

The selected remedy in the On-Post ROD for the structures medium group requires:

"All No Future Use Structures will be demolished.

Agent History structures will be monitored for the presence of Army chemical agent, and treated by caustic washing as necessary prior to disposal.

Both Agent History and Significant Contamination History Group structural debris will be disposed in the on-site hazardous waste landfill.

Other Contamination History Group structural debris will be used a grade fill in Basin A, which will be subsequently covered as part of the soil remediation

Structural assessments and review of ACM and PCB contamination status and disposition of ACM or PCB-contaminated materials will be performed ....

Process-related equipment not remediated as part of the Chemical Process-Related Activities IRA will be disposed in the on-post hazardous waste landfill."

Additionally, the ROD remediation standards that apply to the demolition of structures include:

"Certify 3X decontamination or caustic washes of soil and structural debris to achieve 3X decontamination.

Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.

Demolish all structural material identified in the ROD for landfilling or consolidation.

Remove structural materials with PCB concentrations of 50 ppm or greater that exist above ground level, as well as contaminated parts of floor slabs and foundations identified for removal, and dispose in the on-post TSCA-compliant landfill.

PCB-contaminated sections of floor slabs or foundations that are not identified for removal, and that have PCB concentrations of less than 50 ppm, will be left in place.

All Shell buildings to be demolished during the final remedy will be inspected for equipment containing fluids potentially contaminated with PCBs prior to demolition. Potentially contaminated fluids will be drained and sent off-post for disposal in compliance with applicable TSCA regulations. Equipment that contained these fluids, as well as all other equipment, will be disposed in the on-post TSCA-compliant HWL. The SCH structures will be demolished and the resulting debris will be placed in the on-post TSCA-compliant HWL. The OCH structures will be evaluated by Shell and EPA for any visual evidence of leaks or spills. If observed in areas where potential PCB releases may have reasonably occurred, the affected debris will be disposed in the on-post TSCA-

compliant HWL. Examples of this type of visual evidence would include stains near equipment potentially containing PCB fluids or stains in buildings where there are numerous instances of equipment potentially containing PCB-contaminated fluids.

Removal of asbestos and ACM to attain TSCA requirements.

Meet air quality and odor standards that are ARARs."

Where soil remediation was required to support structures demolition and removal, the ROD remediation standard for soil excavation applies to the demolition projects and requires:

"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the aerial and vertical extent detailed by the soil volume calculations in the administrative record."

The ROD remediation goals that apply to the structure demolition include:

"Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors."

4.4.1 On-Post Structures Remedies Under Construction

4.4.1.1 Miscellaneous RMA Structures Demolition and Removal Phase II #30

The RAOs, selected remedy, remediation standards and remediation goals from the On-Post ROD that apply to the Miscellaneous RMA Structures Demolition and Removal Phase II project are listed in Section 4.4. This project phase was for structures not located in South Plants or North Plants.

The Miscellaneous Structures Demolition and Removal Phase II project is comprised of the following 77 elements:

- Structures: 372, 785, 786, 787, 788, 791, 792, 793, 794, 795, 796, 797, 798, 801, 836, 1605, 1728, NN0202, NN2301, NN2405, UNK
- Miscellaneous Debris Piles: MD0101, MD0102, MD0103, MD0602, MD0603, MD0604, MD0801, MD1101, MD1201, MD1202, MD1203, MD1902, MD2001, MD2401, MD2503, MD2504, MD2601, MD2602, MD2603, MD3001, MD3101, MD3501
- Additional Miscellaneous Debris Piles: MD0104, MD0105, MD0201, MD0203, MD0301, MD0302, MD0303, MD0605, MD1903, MD2201, MD2301, MD2505, MD2506, MD2507, MD2508, MD2509, MD2510, MD2511, MD2701, MD2702, MD2901, MD2902, MD3002, MD3003, MD3004, MD3005, MD3103, MD3104, MD3106, MD3401, MD3502
- Closure of Irondale pipeline and NN28 and NN33

Remediation at the 75 sites involved excavation of P1 Soil; demolition of 21 aboveground and belowground structures; removal of 53 Miscellaneous Debris Piles; closure of Irondale pipeline; backfilling and/or regrading, ripping, and surface revegetation as required. All Agent History debris and ACM was transported to the HWL, and P1 soil from around Structure 836 (Borrow

Area 5), Other Contaminated History debris and miscellaneous debris from debris pile removal were disposed in Basin A and the HWL. P1 soil located around warehouses 795, 794 and 793 (Borrow Area 9C) was stockpiled within Borrow Area 9C for future use by others. In addition to the 75 sites, well abandonment was performed at sites NN28 and NN33 by the Site-Wide Drilling and Sampling Services Project but well closure documentation was referenced in this project's design in order to complete the connection between ROD-listed structures and individual well identifiers. Chemical agent screening was not required during the project because all Agent History Structures were documented ROD 3X certified (agent free) during design.

Disposal of P1 soil, structural debris and miscellaneous debris was documented using a waste tracking system as specified in the RWMP. A total of 1,574 loads of waste were transported to Basin A for disposal. A total of 1,173 loads of waste were transported to the HWL for disposal. Approximately 800 gallons of wastewater was transported to the CERCLA Wastewater Treatment Facility for disposal. A total of 592 tons of scrap metal was transported off-site to a PMC-approved metal recycling facility.

In addition, while conducting the FYR and responding to Regulatory Agency comments, the Miscellaneous Structures Demolition and Removal Phase II project documented, via DCN MSD2-013 (TTECI 2006f), both the disposition of structures that could not be located and the redesignation of some structures for Future Use.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, one confirmatory sample was taken and no CSV soil was excavated. All soils removed were verified by pre- and post-excavation surveys.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the Miscellaneous Demolition Phase II Project.

Permanent seeding was placed by the USFWS at the following former structure sites: 372, 785, 786, 787 and 788 and former debris site MD1902. Interim seeding was placed at the following former structure sites: 791, 792, 793, 794, 795, 796, 797, 798, and 836.

The PMC conducted a Prefinal Inspection Meeting and Site Inspection for the project in conjunction with representatives of the PMC, RVO, EPA, CDPHE, and TCHD. Subsequently, a Final Inspection Meeting was held in which the parties concurred that all field work had been completed and that a final field inspection was not necessary. The CCR was approved on March 30, 2006 (TTECI 2006g).

No caps, covers, or treatment facilities are required by the ROD for this remediation project, therefore no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in the future FYRs.

4.4.2 Completed On-Post Structures Remedies

4.4.2.1 Post-ROD Removal Actions for Structures #18

The RAOs, selected remedy, remediation standards and remediation goals in the On-Post ROD that apply to the Post-ROD Removal Actions for Structures are listed in Section 4.4. The Post-ROD Removal Action for Structures was comprised of two parts: the Interim Building Chemical Related Activities for South Plants and the Administrative Areas Asbestos Remediation Projects.

The Interim Building Chemical Related Activities for South Plants and the associated CCR (WGI 2000) involved removal of chemicals and decontamination liquids from Shell Oil Company occupied structures within South Plants. This effort included partial removal of piping, tanks, and equipment. During the ongoing Chemical Process-Related Equipment Removal Activities, the process equipment that remained in Shell buildings was characterized to ensure that no materials remained in structures that would prevent disposal with the building debris. The pipelines and equipment that remained in the buildings have been opened, drained and, if necessary, rinsed in preparation for disposal.

The Administrative Areas Asbestos Remediation Projects CCR documented completion of asbestos removal projects: Building 111 Stairwell, Class H - Nonfriable; Building 383 - Class II - Nonfriable; and Building 618 - Class I and H - Friable and Nonfriable (PMRMA 2003d). The subject buildings were located in the administrative sections of the RMA. Building 111 is being used for administration. Building 383 was used as the military Post Officer's Club and is currently the USFWS Visitor Center. Building 618 was used as administrative space in the south end of the building, as a Chemical Military Protective Suit Washing Facility in the west end of the building, and the remainder of the building was used as a warehouse to store RMA supplies. Through surveys and sampling it was determined that Building 111 Stairwells and Building 383 contained floor tiles that were made with nonfriable ACM and Building 618 had friable and nonfriable ACM on the interior roof and pipes above the Self-Service Supply Store that was constructed inside.

ACM removal at the above-listed sites involved preparation of project work plans and safety plans, background ACM level monitoring, construction of negative air containments where needed for ACM removal, air monitoring for ACM during and after removal, and proper disposal of the ACM and protective equipment along with preparation of required project documentation.

For each of the three projects, air monitoring of airborne ACM levels was conducted to determine background levels, levels during ACM removal and airborne ACM levels after removal work was completed in compliance with all applicable regulations including 40 CFR 763 Part M. Final Clearance samples were analyzed using Transmission Electron Microscopy Analysis. No samples exceeded applicable federal and state regulatory requirements.

ACM PPE and ACM-contaminated containment structures and other material were properly bagged, sealed, labeled and manifested before they were disposed at appropriate off-site landfills approved by EPA.

As documented in the above CCRs, remedial actions under these projects have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. These projects do not require any long-term O&M. There are no early indicators of potential remedy failure and no adverse results indicated by air, water, or biota monitoring in the area where the remedial actions were implemented. The EPA approved the Interim Building Chemical Related Activities for South Plants CCR and the Administrative Areas Asbestos Remediation Projects CCR on September 29, 2000 and September 29, 2003, respectively.

4.4.2.2 South Plants Structures Demolition and Removal Phase 1 and Phase 2 #29

The RAOs, selected remedy, remediation standards and remediation goals from the On-Post ROD that apply to the South Plants Structures Demolition and Removal Phase 1 and Phase 2 project are listed in Section 4.4.

The South Plants Structures Demolition and Removal Project involved excavation of HHE soil prior to construction of a stormwater retention Basin; construction/remodeling of a decontamination facility; removal of railroad track and ties; removal of overhead electric lines and utility poles; abatement of friable and nonfriable ACM; removal of PCB equipment and debris; removal of mercury switches, light bulbs, batteries and miscellaneous chemicals; reclamation of white phosphorus tank debris and encapsulation in concrete of any pipe debris that could not be reclaimed; demolition and disposal of 199 structures and foundations; and removal and disposal of 10 debris piles. During demolition, agent history structures were screened for chemical agent. There were no confirmed detections of chemical agent during the project and no MEC was found.

Demolition debris and hazardous materials were transported and disposed at the HWL or Basin A. PCBs and ACM were disposed at the HWL. Wastewater not acceptable for on-site treatment, as well as PCB liquids, PCB light ballasts, miscellaneous chemicals and batteries were managed at off-site treatment storage and disposal facilities in accordance with the CERCLA Off-Site Rule and all applicable regulations. Disposal of demolition debris, ACM and PCB wastes was documented using a waste tracking system as specified in the RWMP. Approximately 3817 loads of demolition debris were disposed in the HWL during the course of this project, and approximately 2,916 loads of demolition debris were disposed in Basin A.

Health and safety sampling and analysis were performed by the Subcontractors in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were met or exceeded for the contaminants tested.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. No CSV samples were taken during the project. All soils removed were verified by pre-and post-excavation surveys.

Final revegetation will be accomplished as part of cover construction.

As documented in the CCRs (FWENC 2000j, 2002g), remedial actions under these projects have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. These projects do not require any long-term O&M. The property involved in these projects is subject to restrictions on land and water use, which will be evaluated in future FYRs.

The EPA approved the CCRs for Phase 1 and Phase 2 on September 29, 2000 and July 2, 2002, respectively.

4.4.2.3 Miscellaneous RMA Structures Demolition and Removal Phase I #30

The RAOs, selected remedy, remediation standards and remediation goals from the On-Post ROD that apply to the Miscellaneous RMA Structures Demolition and Removal Phase 1 project are listed in Section 4.4.

The selected remedy in the On-Post ROD for the Additional Components requires:

> *"Stored, drummed waste identified in the waste management element of the CERCLA Hazardous Waste IRA may be disposed in the on-post hazardous waste landfill in accordance with the CDD."*

Phase 1 of the Miscellaneous Structure Demolition Project had four major components. The first major component was Structure Demolition and Removal, which included the following activities: demolition, removal and disposal of 102 structures and foundations; removal and disposal or recycling of four underground storage tanks; removal and disposal of substations; recycling structural steel and other metal components; CSV sampling and analysis, excavation and disposal; removal and disposal of several debris piles; removal and disposal of paved and unpaved roads and parking areas; rotomilling asphalt-paved areas for reuse; backfilling and grading; interim final contour grading and surveying; soil ripping and revegetation. This work included demolition and removal of Bldg. 809 (Irondale Groundwater Treatment System).

The second major component of Phase 1 was the Drummed, Staged and Contained Waste Handling and Disposal Task (Drum Shredding Task). The third major component of Phase 1 was Disposal of Drummed and Miscellaneous Waste from North Plants Task (North Plants Drums Task).

The fourth major component of Phase 1, the Section 36 Boneyard Screening and M139 Bomblet Destruction Task (Section 36 Boneyard Task), was added to the original scope of work in 2001. Under the Section 36 Boneyard Task, ten M139 bomblets were uncovered in the Section 36 Boneyard. The first three bomblets were uncovered in October 2000 during Miscellaneous Structure Demolition Project Phase 1 activities at the site listed as None06 in the project scope of work. None06 was a scrap metal/debris pile located on the old North Plants Parking Lot on the north-central edge of Section 36. Shortly after discovery of the first three bomblets and subsequent confirmation of their GB contents, three more bomblets were confirmed, making a total of six known bomblets at the time that the Phase 1 scope of work at None06 was modified via DCN to incorporate the Section 36 Boneyard Task. Consequently, None06 demolition and removal effort was completed under the Section 36 Boneyard Task. Four additional bomblets were confirmed at a later date during Section 36 Boneyard Task operations, bringing the final total confirmed M139 bomblets to ten. The ten bomblets and their contents were destroyed using a containment structure and state of the art techniques (FWENC 2001f, 2001g). Additional discussion is provided in Section 4.5.1.3. Although cleanup of the Boneyard is part of the remedy selected in the 1996 On-Post ROD, the Boneyard had not been identified as having a potential for RCWM or MEC.

The wastes associated with Phase 1 structure demolition, drum disposal, and drum shredding remedial activities were managed in accordance with the RWMP and design requirements, and disposed according to Section 9.2 of the ROD for structures, and Section 9.4 of the ROD for drum disposal. Waste material from Miscellaneous Structures Demolition was disposed at the on-post HWL, the CERCLA Wastewater Treatment Unit (WWTU) or off-post in accordance with the task-specific waste characterization and waste management plans.

A portion of the waste decontamination fluids from the destruction of the 4 additional bomblets was shipped to the U.S. Army Aberdeen Proving Grounds for a treatability study. With the exception of Bldg. 809, debris from Other Contamination History structures was disposed in Basin A. Bldg. 809 debris was disposed in the HWL after concerns over suspect spent carbon residue on some of the debris were addressed. Debris from Significant Contamination History and Agent History structures and other hazardous materials not disposed off-site was disposed in the HWL or at CERCLA.

During Phase 1, 3,697 loads of waste were transported to Basin A for disposal. A total of 2,147 loads of waste were transported to the HWL for disposal. Waste disposal was documented using the waste tracking system as specified in the RWMP. Several partial loads of containerized waste requiring off-site disposal were delivered for off-site disposal. Approximately 5200 gallons of wastewater from various sumps, vaults, and tanks were transported to the WWTU for disposal. A total of 586 tons of scrap metal were transported off-site to an approved metal recycling facility to be melted for recycle.

During Phase 1, eighteen CSV confirmatory samples were collected as part of the structure demolition and removal effort. Prior to sample collection and analyses, a list of COCs for each potential CSV sample site was established by the RVO and the Regulatory Agencies. Establishment of a COC list was necessary because the ROD did not prescribe task-specific COCs for the Miscellaneous Structure Demolition Project as there was no contaminated soil identified as being associated with miscellaneous structures. A total of 657 cy of soil was excavated as CSV during Phase 1, in accordance with Regulatory Agency direction. All soils removed were verified by pre-and post-excavation surveys.

Health and safety sampling and analysis were performed by the Subcontractors in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were met or exceeded for the contaminants tested.

Revegetation status varies among sites. Most sites received seeding with locally-adapted perennial vegetation, and many have been included in USFWS permanent seeding projects.

As documented in the CCR (FWENC 2002h), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on September 30, 2002.

4.4.2.4 North Plants Structure Demolition and Removal #42

The RAOs, selected remedy, remediation standards and remediation goals in the On-Post ROD that apply to the structures medium group of the North Plants Structure Demolition and Removal project are listed in Section 4.4. The project also included soil, chemical sewer and sanitary/process water sewer remediation.

The selected remedy in the On-Post ROD for the North Plants component of the soil remedy requires:

> *"Excavation and landfill of human health exceedance soil. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. The excavated area is backfilled with on-post borrow material. A 2-ft-thick soil cover is placed over soil posing a potential risk to biota and the footprint of the North Plants processing area."*

The selected remedy in the On-Post ROD for the Chemical Sewers component of the soil remedy requires:

> *"For sewers located outside the South Plants Central Processing Area and Complex Trenches areas, sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced."*

The selected remedy in the On-Post ROD for the Sanitary/Process Water Sewers component of the soil remedy requires:

> *"Void space inside sewer manholes is plugged with a concrete mixture to prohibit access and eliminate the manholes as a potential migration pathway for contaminated groundwater. Aboveground warning signs are posted every 1,000 feet along the sewer lines to indicate their location underground."*

The selected remedy in the On-Post ROD for revegetation is:

> *"Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation."*

The ROD remediation standard that applies to the soil, chemical sewer and Sanitary/Process Water Sewers components of the selected remedy that is not listed in Section 4.4 requires:

> *"Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the aerial and vertical extent detailed by the soil volume calculations in the administrative record."*

The North Plants Demolition and Destruction of Equipment Project was comprised of the following major work activities: structure demolition and removal (59 structures and 2 debris areas), HHE Soil Areas (NPSA-5, NPSA-6), Biota Soil Removal Areas (NPSA-8c, 9f, NPSA-3, 5, 6), upstream and downstream chemical sewer removal (NPSA-1), sanitary sewer removal, destruction of equipment, and GB Fill equipment dismantlement and decontamination (GB Fill Equipment Task).

Separate design analyses were prepared by the RVO and approved by the Regulatory Agencies for the North Plants Demolition Project and the Destruction of Equipment Project. Remediation at the site involved excavation and removal of Chemical and Sanitary Sewers, HHE, Biota, and P1 soils, demolition and removal of all above grade and below grade structures, dismantlement, destruction and removal of GB equipment, backfilling, compacting and interim contour grading, and surface revegetation. All soil and debris were removed and disposed in accordance with the design requirements, which included disposal in the HWL, Basin A and, for certain wastes, disposal off-post in accordance with the RWMP.

As of October 2003, the destruction of all items under the demolition project, the destruction of equipment project and the destruction of the GB fill equipment project was complete and was accepted by international Chemical Weapons Convention Treaty Inspectors. Following the treaty inspection, all remaining items were transported to the HWL for disposal. As a result, the monument that designated RMA as a Chemical Weapons site was removed in December 2003.

Disposal of contaminated soil and debris was documented using a waste tracking system as specified in the RWMP. A total of 12,174 loads of debris were disposed in the HWL and 1,792 loads of debris were taken to Basin A for disposal. A total of 4,780 loads of contaminated soil were disposed in the HWL during the course of this project and 1,479 loads of Biota and P1 soil were disposed in Basin A. Although removal of biota soil was not required by the ROD, biota soil was excavation was incorporated to take advantage of implementation efficiency and to prevent cross contamination between soil and structures debris during the structures demolition and foundation removal. A total of 847,257 gallons of wastewater, typically pumped from sumps, pits, and basements, were hauled to the on-post CERCLA WWTU. Finally, a total of 4,385 tons of steel were removed from the site and recycled.

CSV tracking forms were used to identify, document, track, and record approval for CSV removal and for confirmatory and HHE Removal Verification (verification) soil sample collection and to document Agency approval to backfill excavations and foundation footprints. No CSV soil was excavated during the North Plants Demolition Project. Ninety-four Confirmatory Soil Samples (and three field duplicate samples) were collected for this project. Seventy-two verification samples (plus seven field duplicate samples) were collected for this project. All soils removed were verified by pre-and post-excavation surveys.

A fuel-impacted subsurface soil area was encountered at North Plants during excavation and removal of a chemical sewer. The 1988 Phase I Contamination Assessment Report (Ebasco 1988) identified a known fuel spill (from a 1982 pipe break) in the area of the Building 1717 waste sump, and a soil investigation was conducted in this area during the Phase I and Phase II RI of North Plants. However, during the RI, soil was only analyzed for the gasoline range organic compounds and diesel range organic compounds appeared only as Tentatively Identified Compounds of the semivolatile analyses. The 1989 Final Central Area Study Area Report (Ebasco 1989b) indicated that petroleum-contaminated soil may be present, and provided a map showing the possible distribution of petroleum-contaminated soil, but the presence of LNAPL was not discovered during the RI. LNAPL was first noted in 1993 during routine groundwater monitoring in Well 25055 in the North Plants area, but the LNAPL in this well was not quantified until 2001. A small amount of fuel (approximately 18 gallons) was removed in 2001, but the need for further groundwater characterization was identified.

A fuel-impacted subsurface soil area was discovered near Building 1712 during excavation and removal of the chemical sewers in 2002 and 2003. Approximately 2000 cy of fuel-impacted soil was excavated during chemical sewer removal near Building 1712. Based on the discovery of the fuel-impacted soil in the chemical sewer corridor in the Building 1712 area, additional characterization efforts were initiated to investigate the extent of soil contamination and fuel in groundwater. The soil sample results and fuel measurements are documented in the *North Plants Soil Remediation Project Petroleum-Impacted/Stained Soils Final Data Summary Report* (TTFWI 2004g). Those results were used to prepare the *North Plants Soil Remediation Project Petroleum Release Evaluation Report* (PRER) (TTFWI 2004h). The PRER assessed the remaining soil contamination and determined that no further soil remediation action is required.

However, fuel remains as LNAPL in association with groundwater in the North Plants vicinity. For that reason, LNAPL and groundwater characterization will continue until the full extent of the contamination and the method for remediation, if any, is determined. Additional detail is provided in Section 6.4.1.2.

Final revegetation will be accomplished following completion of the North Plants Soil Remediation Project.

Personal health and safety sampling and analysis was performed in accordance with the National Institute for Occupational Safety and Health Manual of Analytical Methods. The results indicated that no action levels were exceeded requiring PPE upgrade during the North Plants Demolition Project.

On February 6, 2003, a Category 2 (unknown liquid) anomaly was discovered in North Plants. Central dispatch was notified. A laborer tasked with removing debris from a clean backfill area picked up a rusty coffee can that held a glass vial wrapped in cotton batting. Fire and Emergency Services arrived on the scene and conducted a field screen. The field screen was negative and the item was transported by Fire and Emergency Services to the RMA Environmental Analytical Laboratory. The container was a 60-70 ml glass vial containing a brown liquid that was sealed with a ground glass stopper. Under controlled conditions in the laboratory, the liquid was analyzed and neutralized. The results of the analysis estimated the 20ml sample to be 5 percent GB with the remainder DIMP.

On February 11 and 12, 2003, two consecutive Miniature Continuous Air Monitoring System® detections were reported inside the Vapor Containment Structure during operations. In accordance with routine procedures, the Vapor Containment Structure perimeter Depot Area Air Monitoring System (DAAMS) tubes were analyzed. Real-time fenceline monitoring was conducted immediately to assure public safety. The analysis yielded positive detections of GB at levels less than the Airborne Exposure Limit (4-hour time-weighted average of 0.001 milligrams per meter cubed) for GB. As a precautionary measure, the Vapor Containment Structure DAAMS tubes collected February 19, 2003 were analyzed. The analysis yielded positive detections of GB at levels less than the Airborne Exposure Limit for GB. An assessment was performed to review and summarize the possible sources of the confirmed anomalous detections of GB in perimeter DAAMS tubes. The assessment (FWENC 2003e) focused on laboratory and field operations and, at conclusion, could not identify a source for the GB detections.

In September 2004, an ESD entitled "Explanation of Significant Differences for North Plants Structure Demolition and Removal Project" was approved (TTFWI 2004i). The ESD documents the increase in soil excavation volumes associated with the chemical sewers. The increase occurred because the sewers were encountered at much shallower depth than anticipated and soils had to be removed to a total depth of 10 ft. The ESD also documents the change in remedy for the biota soil and the decrease in biota soil volume based on eliminating structures footprints and other asphalt and concrete areas from the excavation boundaries.

As documented in the CCR (TTFWI 2004j), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. Until a formal ROD change is completed, construction of a cover and associated long-term O&M will be necessary in this vicinity. The property involved in this project and waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on September 30, 2004.

4.5 Other Remedies

4.5.1 Other Operating Remedial Actions

4.5.1.1 Site-Wide Biota Monitoring #48

Although included on Table 2.0-2 as an operating project, this subject matter is more appropriately addressed as a topic for data review in Section 6.4.3 and assessment in Section 7.2.3.5.

4.5.1.2 Site-Wide Air Monitoring #49

Although included on Table 2.0-2 as an operating project, this subject matter is more appropriately addressed as a topic for data review in Section 6.4.4 and for assessment in Section 7.2.3.6.

4.5.1.3 Unexploded Ordnance Management #51

The selected remedy in the On-Post ROD for the Additional Component addressing UXO management requires:

> *"Any UXO encountered during remediation will be excavated and transported offpost for detonation (unless the UXO is unstable and must be detonated onpost) or other demilitarization process."*

From a program perspective, the PMC UXO Department is responsible for the PMC component of the RMA munitions response action. PMC management of this action is primarily accomplished through three tasks; each task is intended to address the RMA military munitions-related hazards present during the remedy. These tasks consist of the following:

- Support the RMA On-scene Coordinator during RMA Category I/II Anomaly Responses—anomaly responses may result in recovered MEC and/or RCWM.
- Manage and/or perform military munitions-related operations on the RMA confirmed munitions response areas/sites.
- Provide military munitions-related construction support during remedial efforts which have the potential to result in recovered MEC, RCWM, and/or munitions debris.

Consistent with munitions response actions performed under CERCLA, it is not possible to state that all potential hazards resulting from previous military munitions-related operations on RMA have been removed as a function of the RMA iteratively-approved munitions response action. The Army responsibility for military munitions-related hazards on RMA is nontransferable and will remain with the Army after the RMA remedy is complete. This said, prior to remedy completion the RVO has committed to provide the USFWS with military munitions awareness training. This training is intended to heighten USFWS personnel awareness of military munitions-related hazards and to inform the USFWS of the Army notification process, if potential military munitions are encountered by Refuge employees/patrons after Remedy completion. The Army-provided awareness training is not intended to grant the USFWS or its representative authorization to perform any action on potential military munitions but to ensure notification and response by trained Army representatives (PMRMA 2006a).

With one exception, all UXO and discarded military munitions recovered during the FYR period have been considered unstable and were explosively disposed on-post using donor explosives. MEC recovered on RMA have been subjected to extreme heat, shock and friction as a result of some variation of a previous functioning/disposal attempt. MEC subjected to these types of forces are considered unstable. The degree of instability is left to the munitions response experts, based upon extensive publication research and previous experience. At RMA, the degree of instability has consistently been determined to be safe for on-site transportation, with five exceptions, where the items were blown in place. However, the assurance of safely transporting off-site is highly subjective, essentially requiring the MEC to be in as-manufactured condition. Given those considerations, the MEC has been determined unsuitable for transportation offsite.

The one exception was five (5) M56 warheads (components of the M61 rocket) recovered during Part I of the Burial Trenches/Munitions Testing remedy. U.S. Army Technical Escort Unit personnel confirmed the warheads as simulant-filled (ethylene glycol) and/or explosive-filled (Tetryl). The U.S. Army Technical Escort Unit assumed custody of the M56 warheads and transported the warheads off-post. Based on information provided by UXO management staff, it was determined that monitoring, transportation, and explosive disposal of UXO/discarded military munitions on-post was conducted in accordance with Department of Defense Standard 6055.9, Army Regulation 385-64, Army Regulation 75-15, and Department of Army Pamphlet 385-64. The provision of the On-Post ROD cited above has been met.

Additionally, as noted in Section 4.4.2.3, on October16, 2000, personnel conducting cleanup activities as part of the Miscellaneous Structures Demolition and Removal Project discovered an M139 bomblet in an area referred to as the Section 36 Boneyard (Boneyard). Continued activities in the Boneyard during November 2000 resulted in discovery of five additional bomblets. U.S. Army Technical Escort Unit munitions experts evaluated the bomblets and determined that the bomblets contained the nerve agent GB.

Upon discovery of the first bomblet, the Army initially proposed to destroy it using explosive neutralization. Other technologies were reviewed including the use of a Donovan Chamber and caustic digestion procedures. After presenting an initial plan to the Regulatory Agencies, and the subsequent discovery of the five additional bomblets, discussions were initiated which eventually resulted in selection of a newly developed treatment system for bomblet disposal called the

Explosive Destruction System. The Explosive Destruction System demilitarizes munitions through detonation followed by the introduction of a chemical reagent in the vessel to neutralize any chemical agent. As part of the Explosive Destruction System plan, the Boneyard was covered by a Local Area Maintenance Shelter to provide containment and a temperature-controlled working environment. Air circulated through the Local Area Maintenance Shelter was vented through a carbon filtration system prior to being released to the atmosphere. Air monitoring was conducted outside the Local Area Maintenance Shelter at the perimeter of the worksite and around RMA to confirm that there were no releases from the project site. Destruction of the six bomblets occurred during late January and early February 2001 (FWENC 2001f).

The Local Area Maintenance Shelter also served as a containment structure while the remainder of the Boneyard debris was inspected and removed for disposal. During final cleanup of the Boneyard in June 2001, an additional four M139 bomblets were uncovered, making a total of ten bomblets discovered in the Boneyard. The additional four bomblets were destroyed in July 2001 using the Explosive Destruction System (FWENC 2001g).

During bomblet discovery and destruction operations, public notification procedures and outreach were enhanced to address the heightened need for up-to-date and accurate information regarding destruction options for the bomblets and public safety. Daily updates of the bomblet status were posted on the RMA website, fact sheets were distributed door-to-door in nearby communities, media were briefed daily, and a fully revised call-down list including members of Congress and community members was developed. These procedures will be reviewed and updated periodically for continued use in the future.

The Explosive Destruction System operations successfully destroyed all ten bomblets that were found on RMA. Analytical data associated with the operations show that no GB was detected in any of the neutralant samples. In addition, near real-time air sampling data show that there were no detectable concentrations of GB released outside the Vapor Containment Structure. Solid wastes generated during Explosive Destruction System operations were disposed in the on-site HWL. The neutralant was transported to an off-site incineration facility for disposal. The rinsate liquids were disposed on site at the CERCLA WWTF. Although data show that GB was detected in the headspace of several samples, additional supporting data show that the Explosive Destruction System vessel effectively contained the vapors during destruction operations. During destruction of the ten bomblets, there were no agent releases to the environment and all of the associated wastes were handled in accordance with the approved plans.

Although cleanup of the Boneyard is part of the remedy selected in the 1996 On-Post ROD, the Boneyard had not been identified as having a potential for RCWM or MEC.

Beginning as early as 1973, the Army began assessing the potential contamination, including UXO, associated with activities from RMA. Studies reviewed historical documents during RMA operations, geophysical surveys, personnel interviews, field inspections, and aerial photographs. The Army, however, did not have the capability of reviewing aerial photographs from year to year to analyze changes and identify anomalies to the extent that this evaluation does. Advances in computer imaging and mapping technology, coupled with powerful Geographic Information

System software, have improved not only the quality of the photographic record but have made it useful to develop a larger and more complete photographic record.

A three-pronged approach was developed to ensure that all aspects of the RMA project incorporated more complete measures to identify potential MEC and RCWM hazards and to address any future discoveries of MEC and RCWM. First, a team of technical staff members from the Army, Shell, USFWS, EPA, CDPHE, and TCHD was formed to conduct the RMA-wide evaluation of potential MEC and RCWM hazards at RMA (Evaluation Team 2002). The Evaluation Team reviewed information from the Administrative Record pertinent to MEC and RCWM, conducted a comprehensive review of historical aerial photographs using new state-of-the-art technological capabilities, and performed field investigations to determine the need for remediation. The principal focus of this evaluation was to identify areas that may indicate the presence of production, demilitarization, storage, testing or disposal of MEC or RCWM, particularly areas not identified in the ROD as having UXO or agent potential.

The evaluation of MEC and RCWM hazards at RMA contained the following major elements:

- Review of aerial photographs of RMA and identification and review of observed anomalies
- Review of historical documentation, including reports, geophysical surveys, interviews and depositions, with regard to potential MEC and RCWM hazards
- Field investigation of anomalies that could not otherwise be explained
- Integration of the results from the document review, aerial photograph review, and field investigations into a section summary and hazard evaluation

Second, the RMA Emergency Response Integrated Contingency Plan was revised. The Integrated Contingency Plan provides a framework for response to unplanned incidents that occur at RMA. The Integrated Contingency Plan identifies emergencies that could develop, especially during the conduct of cleanup activities such as the Burial Trenches project or as occurred at the Section 36 Boneyard site. The Integrated Contingency Plan previously addressed the potential discovery of UXO and RCWM. The revised Integrated Contingency Plan addresses the discovery of MEC as well and has modified the response process based upon lessons learned from the bomblet discovery experience.

Third, the Visitor Access Plan and public notification procedures were revised. Visitor access for both the environmental education programs and professional courtesy tours (not essential to RMA work) was suspended after the first bomblet was determined to contain GB.

Following bomblet discovery, public notification procedures and outreach were enhanced to address the heightened need for up-to-date and accurate information regarding destruction options for the bomblets and public safety. Daily updates of the bomblets' status were posted on the RMA Web site; fact sheets were distributed door-to-door in nearby communities; media were briefed daily; and a fully revised call-down list was developed, including members of Congress and community members.

The rigorous and comprehensive, year-long evaluation of potential MEC and RCWM hazards in the 28 sections that comprise RMA was completed in late December 2001. The aerial photograph review identified 2,600 manmade and sometimes natural features referred to as anomalies. Of these, the historical documentation and/or aerial photograph analysis provided sufficient information to confidently eliminate more than 1,800 anomalies from consideration as a potential MEC or RCWM concern. Another approximately 600 anomalies were eliminated after further extensive document review and photograph stereo pair review.

More than 450 anomalies were identified as being within already completed ROD-identified remediation project areas or future ROD remediation project areas. While most of these anomalies were eliminated, 30 anomalies were identified with potential hazards in future remediation areas. Although the evaluation for potential MEC and RCWM hazards is already part of the design process, these 30 anomalies were specifically identified to the design teams for inclusion in the design evaluation. For upcoming remediation projects, potential MEC and RCWM hazards will be evaluated and documented in the remedial designs. For already completed projects, potential MEC and RCWM hazards were addressed during remediation design and implementation.

A total of 170 anomalies could not be satisfactorily identified from review of the historical documentation or other existing information. Field investigations, which included visual observation during field walks and/or excavation of potholes or exploratory trenches, were conducted at each of the 170 locations. Based upon the results of these investigations, 4 sites were identified with potential MEC hazards and have been designated for remediation as part of the ROD-identified Burial Trenches Soil Remediation project.

Two additional sites were identified with potential MEC hazards based on historical document review and were designated for remediation. These two sites will be addressed by the Munitions Testing Soil Remediation Project Part 2 #25.

Five of the six sites identified for remediation are located in the eastern sections of RMA (Sections 29, 30 and 32) where the Army conducted various munitions-related activities. In addition to identified testing and disposal areas, the team noted that there was surface and subsurface metal and debris (such as shell casings, metallic packaging components, tools, vehicle and equipment parts) scattered throughout the eastern sections of RMA. Subsequently, surface sweeps were performed to identify and clear the areas of munitions debris. Characterization activities did not result in discovery of any MEC, UXO or RCWM outside of remediation areas. While the characterization efforts are focused on individual debris items, this evaluation focused on identifying production, demilitarization, storage, testing or disposal areas where MEC or RCWM hazards are likely. In the eastern sections, although debris is common in places, this evaluation provides strong evidence that production, demilitarization, storage, testing or disposal areas were identified.

The findings of this evaluation solidified the Army understanding of MEC and RCWM activities at RMA. The findings from this evaluation confidently answer questions remaining about UXO, MEC and RCWM and the results are in agreement with the site use history based on the record. The evaluation team performed a critical assessment of documentation for each anomaly until the anomaly was resolved and consensus of the group, which included representatives from Regulatory Agencies and RVO, was reached. The evaluation used state-of-the-art computer imaging, mapping technology, and software. This capability had not existed previously and allowed the Evaluation Team to conduct a comprehensive evaluation as demonstrated by the identification of the six new remedy sites. While no technique or evaluation is flawless, the current evaluation approach was thorough and the future discovery of additional sites with MEC or RCWM hazards is highly unlikely.

As noted above, the Evaluation Team Report noted areas of subsurface metal and debris (such as shell casings, metallic packaging components, tools, vehicle and equipment parts) scattered throughout the eastern sections of the RMA. As a result, it was agreed that dense surface munitions debris would be identified by a visual surface inspection of 11 areas in Sections 4, 6, 19, 20, 26, 29, 30, 32, 34, 35, and 36. A work plan was prepared to ensure a systematic approach to the inspections (FWENC 2002i). Ultimately, dense surface munitions debris was identified in 5 areas in Sections 6, 30 and 32. A surface sweep and munitions debris removal were performed (FWENC 2003f).

4.5.1.4 Medical Monitoring Program #52

The selected remedy in the On-Post ROD for Medical Monitoring required that a medical monitoring program be instituted that would respond effectively to RMA-related health concerns of the surrounding communities during the soil cleanup. CDPHE has the lead role in the medical monitoring program. The ROD also stipulated that a Medical Monitoring Advisory Group be formed to recommend appropriate program components. As directed by the ROD, the Medical Monitoring Advisory Group had representation from the affected communities including Commerce City, Montbello, Henderson and Green Valley Ranch, from public health agencies including CDPHE, Agency for Toxic Substances and Disease Control, EPA, Denver Department of Environmental Health and TCHD, as well as from Army, Shell Oil Company, USFWS, independent technical advisors and the Site-Specific Advisory Board.

The Medical Monitoring Advisory Group completed its work in October 1998 and submitted a final report to CDPHE for acceptance. CDPHE formally accepted all twelve of the program recommendations developed by the Medical Monitoring Advisory Group and began program implementation. The program recommendations include systematic evaluation of air quality data and its health significance, a medical referral system to track and respond to community health concerns, systems to monitor birth defects and cancer in the neighborhoods around RMA, improvements to the RMA air quality and odor monitoring programs, improvements to emergency response programs, a process for selecting appropriate public health actions, health professional education and public involvement and education.

Key program accomplishments during the FYR period include:

- The CDPHE continued to collaborate with Rocky Mountain Poison and Drug Center to provide 24-hour, expert assistance for citizens and health care providers who may have RMA-related health questions. Inquiries received through the *RMA Health Line* are systematically tracked for patterns or trends. The CDPHE ensured that the Rocky Mountain Poison and Drug Center staff remained abreast of air quality monitoring data and RMA activities with the potential to impact the air pathway or receive public attention, including conventional ordnance destruction events, prescribed burns, the GB bomblets discovery and destruction, potentially liquid-filled ordnance discoveries and visitor access suspension, and dust, emission or odor episodes. The CDPHE and the

RVO provided the Rocky Mountain Poison and Drug Center information sessions on the RMA COCs, the air monitoring program, and birth defects and cancer surveillance results. Since *RMA Health Line* inception in December 1998 through March 2005, 1193 calls have been received: 1132 callers (95 percent) listened to the Health Line information recording only and 61 callers (5 percent) consulted directly with a nurse. Of these 61 callers, 23 callers asked general RMA, non-health-related questions and 19 calls related to personal health concerns of the caller or family member. In these 19 cases, the Rocky Mountain Poison and Drug Center physicians, collaborating with the CDPHE, determined that it was unlikely that the caller's symptoms were related to the RMA cleanup, but offered to consult with caller's physician. The Rocky Mountain Poison and Drug Center and CDPHE collaborated on many of the health concern calls to collect and evaluate personal, environmental and public health data relevant to the caller's concerns. The Health Line remains an effective service for prompt response to citizens' concerns. The Health Line is also a useful system for CDPHE to maintain passive surveillance of community health concerns.

- CDPHE continued to systematically evaluate RMA air quality monitoring data for its public health significance. Results to date have been within site-specific limits.
- Cancer incidence in the communities surrounding the RMA is being tracked before, during and after the soil cleanup. CDPHE finalized two cancer surveillance reports: one for the 18-year baseline reporting period prior to beginning the RMA cleanup and a second for the period 1997 through 2000. Thirty types of cancer were evaluated. Since the soil cleanup began, the overall number of cancer cases (i.e., all cancer combined) in the RMA study area was generally not higher than would be expected. There were higher rates of specific types of cancer, but no indication they were related to living near RMA.
- An existing state program, Colorado Responds to Children with Special Needs, is being used to track birth defects in the neighborhoods around the RMA during the remediation. Birth defect rates are being tracked and analyzed temporally and spatially. Rates in the communities were found to be stable and similar to rates for all of Colorado for the eight-year period prior to the beginning of soil remediation. Continued monitoring through March 2005 has shown that community rates have not increased above the baseline rates beyond that expected due to random fluctuations. No unusual geographic groupings have been identified. Children with birth defects born in the RMA study area continued to be referred monthly to early intervention services and support groups through Colorado Responds to Children with Special Needs Community Notification and Referral Program. During the FYR period, 624 children were referred to local agencies.
- CDPHE continued to receive program implementation advice from the Medical Monitoring Program Citizen Advisory Board. This advice is based in part on medical monitoring program staff reporting the findings of program components to the Citizen Advisory Board. The program also facilitated reporting by the RVO. The Citizen Advisory Board met 17 times during the FYR period.
- CDPHE established a website in Summer 2001. This website provides program background and implementation information, health surveillance results, Citizen Advisory Board meeting information, contact information, and a Geographic Information

System-based search function which allows citizens to access fenceline and community air quality monitoring results.

- Program goals and results continued to be communicated through RMA and community events, Citizen Advisory Board meetings, the program's *Health Matters* newsletter (seven issues published in English and Spanish since March 2000), the website and brochures, meetings with elected officials and local health departments, and individual contacts.
- In 2003, CDPHE notified health care providers that the Health Care Provider Resource Notebook had been updated and that the notebook was now available on the program website.
- The Emergency Preparedness Implementation plan was finalized in October 2001.

As directed by the Medical Monitoring Advisory Group recommendations, the Medical Monitoring Program has monitored the success of exposure prevention efforts during the first seven years of the soil remediation. The program has also addressed potentially RMA-related health concerns through its toll-free health information line and birth defects and cancer monitoring. Further, the program has responded effectively to unanticipated events that could impact the air pathway. For example, the CDPHE convened the Health Response Review Panel in December 2000 to review public health preparedness at it related to the GB bomblets discovered at the RMA. The purpose of the Health Response Review Panel is to work collaboratively to identify potential or existing public health risks and identify appropriate public health needs and actions. The Health Response Review Panel is made up of representatives of the CDPHE, Denver Department of Environmental Health, EPA and TCHD. The Health Response Review Panel developed nine bomblet-related recommendations for the RVO, all of which were accepted. Following the M-1 Pits "blue haze" odor event in September 2001, CDPHE contacted employees of Recycled Materials, Inc. to determine whether they desired information about the RMA chemicals that were the likely source of odors and physical irritation, in addition to the information already provided by the RVO. CDPHE also developed for the Rocky Mountain Poison and Drug Center an incident and corrective action summary and provided toxicological and air monitoring data. In September 2002, the CDPHE advised the Rocky Mountain Poison and Drug Center of the elevated chloroform measurements and odors associated with the South Plants Central Processing Area soil excavation activities. The Rocky Mountain Poison and Drug Center was kept abreast of air monitoring results, corrective actions and project progress.

4.5.1.5 Operation of CERCLA Wastewater Treatment Facility #60

The CERCLA Wastewater Treatment Unit (WWTU) is a facility providing ongoing support to various RMA remedial projects. Although it began as an IRA, and has been included as part of the ROD, it continues as an integral part of the ongoing remedy. The facility has been operating in batch mode in compliance with all On-Post ROD specifications. All liquid discharges to the Basin A Neck recharge trenches have met appropriate discharge standards. All solid wastes generated have been properly disposed of either off-site or on-site in the HWL. The facility is therefore meeting all applicable provisions of the On-Post ROD.

4.5.2 Other Completed Remedial Actions

4.5.2.1 Western Tier Parcel (deletion) #53

Although the Western Tier Parcel (Deletion) is not a project tracked in the RDIS, due to its importance at that time it was included as an "Other Project" in the 2000 FYR. To avoid confusion and ensure items in the 2000 FYR are closed out, the following information is being provided. The impacts of this change in land use on exposure pathways will be assessed in a more general sense in Section 7.4.7.

The Western Tier Parcel deletion from the NPL and the transfer (sale) to Commerce City, Colorado were accomplished on January 21, 2003 and June 21, 2004, respectively.

In the NODp, EPA noted the following:

> *"The Environmental Protection Agency (EPA) Region 8 announces the deletion of the Western Tier Parcel of the Rocky Mountain Arsenal National Priorities List (RMA/NPL) Site from the National Priorities List (NPL)...*
>
> *EPA and the State of Colorado, through the Colorado Department of Public Health and Environment (CDPHE) have determined that the Western Tier Parcel of the RMA/NPL Site poses no significant threat to public health and the environment and, therefore, no further remedial measures pursuant to CERCLA are appropriate...*
>
> *On October 2, 1998, EPA published a Notice of Intent for Partial Deletion...Comments received during the public comment period primarily focused on the potential future placement of a child daycare facility at the Parcel and reiterated previous concerns that RMA and hence the Western Tier Parcel might be contaminated with dioxins. Based upon consideration of these concerns, EPA postponed action on the partial deletion until additional soil sampling and analysis of the Western Tier Parcel could be conducted.*
>
> *The additional soil studies have been completed and, taken together with previous site-wide risk studies, address the community concerns regarding any future child daycare facility and potential dioxin contamination...*
>
> *EPA proposed the partial deletion of the Western Tier Parcel on September 23, 2002... Comments received during the public comment period, which ended November 22, 2002 were primarily focused on how potential contamination or munitions would be addressed if found during development of the Parcel...*
>
> *In our Responsiveness Summary, EPA explained that the Tri-County Health Department (TCHD) is coordinating with Commerce City, the most likely purchaser of the Parcel to provide personnel who will be available to brief contractors about the RMA/NPL Site history before any activity begins on the Parcel."*

Subsequently, consistent with the Rocky Mountain Arsenal National Wildlife Refuge Act, 1992, on June 21, 2004, 917 acres of the Western Tier parcel was sold to Commerce City, Colorado. The use of the property was restricted to open space or commercial use, and may not be used for industrial or residential purposes.

As documented, remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. There are no early indicators of potential remedy failure and no adverse results indicated by air, water, or biota monitoring in the area where the remedial actions were implemented.

4.5.2.2 Trust Fund #54

The selected remedy in the On-Post ROD for the Additional Component entitled "Trust Fund" requires:

> *"During the formulation and selection of the remedy, members of the public and some local government organizations expressed keen interest in the creation of a Trust Fund to help ensure the long-term operations and maintenance of the remedy . . . In response to this interest, the Parties have committed to good-faith best efforts to establish a Trust Fund for the operation and maintenance of the remedy.... The Parties recognize that establishment of such a Trust Fund may require special legislation and that there are restrictions on the actions federal agencies can take with respect to proposing legislation and supporting proposed legislation. A trust fund group will be formed to develop a strategy to establish the Trust Fund."*

The ROD identified the remedy to be implemented for the RMA site. After the construction phase of the remedy, continued remedial activities (e.g., pumping and treating of groundwater), continued maintenance of structures designed to isolate and prevent the escape of hazardous waste at the site (e.g., soil covers and landfills), and continued monitoring (e.g., of groundwater and surface water) are required. These activities fall under the long-term O&M portion of the remedy and were estimated to cost approximately $5 million per year in 1995 dollars.

During the development of the ROD, members of the public and some local governmental organizations expressed keen interest in the creation of a trust fund to help ensure that the long-term O&M obligations of the Army would be performed. This provision was included because, at the time of the ROD, there was concern that Congress would severely cut funding for the cleanup of RMA, leaving the remedy incomplete. The ROD provided for the formation of a trust fund group to develop a strategy to establish such a trust fund, and in August 1996 a Trust Fund Work Group ("the Group") was established. The Group consisted of representatives from the Parties, the Restoration Advisory Board, the Site-Specific Advisory Board, the Governor's office, Commerce City officials, and the public. The first meeting was held August 14, 1996 and monthly meetings were held thereafter. The Group was co-chaired by a member of the Colorado Attorney General's office (Ms. Casey Shpall), Commerce City (Tim Gagen), and the Restoration Advisory Board (Roland Russell). The Group identified eight possible options for establishing a trust fund and, after much study and discussion, agreed that two options were the most feasible.

The first option consisted of establishing a trust fund under the auspices of the EPA, which had received approval from the Office of Management and Budget to establish trust funds at its Superfund sites. Under this Option, the Army would enter into an agreement with EPA, under which EPA would establish an interest-bearing sub-account for RMA within the Superfund Trust Fund. The second option consisted of Shell placing $5 million in an interest-bearing trust fund established directly as an RMA response action project in lieu of making the payment to the Army as part of its cleanup costs. In return, Shell would receive credit for this expenditure as an allocable cost at the time of the deposit against the periodic payments due under the Settlement Agreement and the FFA.

Representatives of the Group met with EPA Region 8 authorities and contacted EPA Headquarters to discuss the first option. After several meetings with Region 8 authorities and phone conversations with Headquarters EPA, it was determined that because RMA was an active military installation, the EPA Superfund Trust Account could not be used to establish a trust fund for RMA. More specifically, Army money recovered from Shell could not be placed into the Superfund account because the recovery was not on behalf of the Superfund. Also, the CERCLA section governing the Superfund Account (42 USC § 9611(e)) states that no money in the Superfund is available for remedial actions at federally owned facilities with certain limited exceptions, none of which included O&M activities.

A series of letters were exchanged between the Group and Mr. Raymond Fatz, Deputy Assistant Secretary of the Army (Environment, Safety and Occupational Health) regarding the second option. As stated previously, a condition of the second option was that the Army consider the Shell payment into a trust fund as an allocable response cost for which Shell would obtain credit under its financial agreements with the Army. In addition to the series of letters, representatives of the Group met to further explain the second option. It was determined that the second option was legally unacceptable. Under fiscal law constraints, monies payable to the Army by Shell are considered response costs and must be managed under the same rules that apply to appropriated funds. Those rules dictate that response costs must be deposited in the U.S. Treasury and may not be placed in an interest-bearing account absent special legislation.

The last remaining option considered by the Group was to seek legislation to modify the Schroeder Account to fund the O&M trust account. All payments by Shell under the Settlement Agreement with the Army are currently deposited into the so-called "Schroeder Account," a special non-interest bearing account set up by Congress in 1986 to allow the Army to spend the funds deposited by Shell without a separate Congressional appropriation. This account is of great benefit to activities at RMA, because major projects can be accomplished without waiting for Congressional appropriation. Meetings were held with Representative Diana DeGette and members of her staff regarding pursuit of legislation to establish the Trust Fund. This option was not pursued, however, due to concerns by the Army and Shell that such efforts might lead Congress to abolish or otherwise modify the Schroeder Account, if it was again brought to the attention of Congress. This view was also supported by Commerce City representatives. At this point, all further work on the Trust Fund came to an end (PWT 2006).

Accordingly, the only remaining alternative was to seek appropriate legislation. At that time the Army and Shell determined that they had performed "good-faith best efforts" to establish a Trust Fund. The Group discussed seeking the necessary legislation, but following contacts with Colorado congressional representatives it was determined that such an effort would be unsuccessful and no further meetings were held. In light of these unsuccessful efforts, made in good faith, this task is complete.

5.0 PROGRESS SINCE 2000 FIVE-YEAR REVIEW

5.1 Protectiveness Statements from 2000 FYR

The protectiveness statements presented below are quoted from the 2000 FYR:

> *"The protection of human health and the environment by the remedial actions at both the On-Post and Off-Post OU are discussed below. All controls are in place to adequately minimize risks. Because the remedial actions at both the On-Post and Off-Post OU are expected to be protective of human health and the environment upon completion, the remedy for the entire site is expected to be protective of both human health and the environment.*
>
> ***On-Post Operable Unit***
> *The remedy at the On-Post OU is expected to be protective of human health and the environment upon completion. All immediate threats have been adequately addressed in the form of IRAs and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the On-Post ROD, as appropriate. The HWL, which is central to the effective implementation of the remedy, has been expeditiously constructed and is operational. All other implementation projects are on schedule and in compliance with all elements of the On-Post ROD. Air, water, and biota monitoring programs are comprehensive in their design and effective in their implementation. Contaminant migration is being adequately controlled. Risks to human health and the environment are also being controlled by a comprehensive worker protection and access control program, institutional controls and the past implementation of IRAs.*
>
> ***Off-Post Operable Unit***
> *The remedy at the Off-Post OU is expected to be protective of human health and the environment upon completion. All immediate threats have been adequately addressed in the form of IRAs and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the Off-Post ROD, as appropriate. Administrative controls to protect the public have been effective in their implementation. Groundwater contamination is being treated to Off-Post ROD remediation goals both at the RMA boundary as well as at the Off-Post Groundwater Intercept and Treatment System."*

5.2 Status of Recommendations and Follow-Up Actions from 2000 FYR

5.2.1 Basin F Wastepile

The 2000 FYR concluded:

> "*Although no new action is recommended to address the deficiency noted in Section 8.1.1, the collection system and the leachate levels should continue to be carefully monitored on a daily basis until the wastepile is addressed as directed in the On-Post ROD. The On-Post ROD requires the Basin F Wastepile to be re-excavated and placed in the ELF currently scheduled to begin operation in September 2004."*

The RVO took the following actions as a result of the 2000 FYR. Basin F Wastepile and Collection System leachate levels were and continue to be carefully monitored depending on leachate volume generation trends. Current leachate volume (25,641 gallons in calendar year 2004) has now leveled off after consistently and dramatically declining (24,650 gallons in calendar year 1999, 81,336 gallons in calendar year 1990) due to the dewatering of the waste. The On-Post ROD requires the Basin F Wastepile to be excavated and placed in an on-site triple-lined landfill, which began accepting Basin F Wastepile waste in April 2006. The above-described actions taken to date have achieved the intended purpose.

5.2.2 Off-Post Institutional Controls

The 2000 FYR concluded:

> *"The following are recommendations and follow-up actions for improving the well notification program. They should be implemented no later than three months after the issuance of this report.*
>
> - *The SEO has the responsibility of providing notification to well permit applicants. RMA will set up periodic meetings (e.g., annually) with the SEO staff to review the status of well applications from the potentially affected area. The purpose of the meetings will be to determine whether SEO correspondence associated with the applications includes the proper notification.*
> - *The SEO will provide the Army and TCHD copies of all well applications for the potentially affected area.*
> - *When warranted, RMA will request TCHD to make individual contact with well applicants to provide detailed explanation of the nature and extent of groundwater contamination in the off-post area."*

The Army took the following actions as a result of the 2000 FYR. Representatives from Army and TCHD met with personnel from the SEO on July 31, 2001. The purpose of the meeting was to update the SEO on the results of the first FYR related to the institutional control program, to provide a new Well Permit Notification Map, and to review the list of Regulatory Agencies and individuals who should receive copies of permits, e.g. the Army, EPA, and TCHD. The meeting was followed up with an August 28, 2001 letter to the SEO summarizing the discussions and formally transmitting the 1999 RMA CSRG Exceedance Map, the Well Permit Notification Map, and the list of personnel from the Army, EPA, and TCHD to be copied on well permits issued in the notification area (RVO 2001a).

Other follow-up included an CSRG Exceedance Map based upon 2002 data sent to the SEO on December 16, 2003 (RVO 2003b), a Well Permit Notification Map based on 2002 data sent to the SEO and Regulatory Agencies on February 19, 2004 (RVO 2004f), a CSRG Exceedance Map based on 2004 data sent to the SEO on November 8, 2005 (RVO 2005), and a Well Permit Notification Map based on 2004 data sent to the SEO and Regulatory Agencies on June 30, 2006 (RVO 2006c).

A TCHD review of well permits issued in this FYR period has identified that the SEO has not consistently provided the required notification to affected well permit applicants and copies of permits are not routinely being transmitted to all required parties (TCHD 2005). Additional status information is provided in Section 4.2.1.3, an assessment of the Off-Post Institutional Controls is made in Section 7.2.2.3, the Off-Post Institutional Controls are identified as an issue in Section 8.13, and recommendations for follow-up are provided in Section 9.11.

5.2.3 Quantitation Limits

The 2000 FYR concluded:

> *"Beginning with this first Five-Year Review Report, the following procedure is implemented. Individual contaminants at individual groundwater systems have quantitation limits that are conceptually defined as either PQLs or MRLs in the "quantitation limit" column of Table 14.*
>
> *The quantitation values associated with the MRLs are defined by the procedures in Appendix A of the RMA CQAP, and depend on the availability of contract laboratories as well as the ability of these laboratories to maintain their method detection and reporting limits. During each Five-Year Review, existing MRLs will be reviewed and if appropriate, a new MRL will be agreed upon for the upcoming five-year cycle.*
>
> *The selection of a new MRL depends on the following three factors:*
>
> - *The establishment of new MRLs by various laboratories under contract to RMA*
> - *The reliability of the established MRL being considered reproducible over the upcoming five-year cycle*
> - *The professional judgment of the Five-Year Review Team conducting the review*
>
> *The quantitative value associated with the PQLs will be the State of Colorado PQLs as defined in 5 CCR 1002-61, Colorado Discharge Permit System Regulations.*
>
> *After the MRLs and PQLs have been redefined at the Five-Year Review, it is conceivable that changes could occur in these quantitation limits due to laboratory changes, method changes, or other events. The MRLs may vary whenever a new laboratory is put under contract, or whenever a laboratory under current contract conducts proficiency testing (required once every three years) to redefine their operating parameters.*
>
> *In the event that lower quantitation limits become available, adoption of these limits will be considered during the next Five-Year Review. In the event that quantitation limits go up, a letter will by sent my RMA to the EPA, CDPHE, and TCHD notifying them of the change and proposing action as appropriate. As has been the case the past in obtaining analytical services, laboratories will be required to meet ROD-specified quantitation limits. In the event that an analytical method change is proposed, a letter will be sent by RMA to EPA, CDPHE and TCHD prior to adopting the new method notifying them of the proposed change and the anticipated impact on quantitation limits."*

The Army took the following actions as a result of the 2000 FYR. The procedure outlined in Paragraph 9.1.1 of 2000 FYRR requires Army to notify the Regulatory Agencies when a MRL or PQL value increases above those numbers identified in the previous FYRR. This notification was sent to the Regulatory Agencies in a PMRMA letter dated October 12, 2004 (PMRMA 2004c). The increases in MRLs and PQLs occurred on December 18, 2001 and November 21, 2002, therefore, the notification sent by the PMRMA letter dated October 12, 2004, should have been sent twice, and earlier, in January 2002 and in December 2002, closer to the actual dates of change in the MRLs and PQLs. However, despite the deficiency in timeliness, the above-described actions taken to date have achieved the intended purpose.

To correct the timeliness deficiency described above, Army acted in October 2004 to institutionalize the notification process of quantitation limit increases into policies throughout the organization, to ensure that future notifications will be transmitted to the Regulatory Agencies in a timely manner.

5.2.4 Endrin ARAR

The 2000 FYR concluded:

> *"...the Endrin ARAR should be changed from 0.2 to 2.0 in the On-Post and Off-Post RODs. This change should be effected via an Explanation of Significant Differences (ESD) to be completed no later than six months after the issuance of this report."*

In November 2001, an ESD was issued for Endrin CSRG in On- and Off-Post RODs (PMRMA 2001b). The ESD changes the endrin CSRG for the NBCS, NWBCS, BANCS and OGITS, from 0.2 micrograms per liter (µg/l) to 2.0 µg/l, to coincide with the Colorado Water Quality Control Commission April 30, 1996 action to adopt the Federal Maximum Contaminant Level as the CBSG for endrin. It was determined by the EPA, Army, and CDPHE that the remedy, as modified, remains protective of human health and the environment.

5.2.5 CERCLA Compliance Document for the Landfill Wastewater Treatment Unit

The 2000 FYR concluded:

> *"During the next annual review of the LWTS CCD the revised Federal Water Quality Criteria detailed in the FYR Report should be taken into consideration and changes, as appropriate, should be incorporated."*

The Army took the following actions as a result of the 2000 FYR. As agreed by all stakeholders in a December 1, 2002 Amendment to the CCD, the CCD should be updated after every FYR, not annually, as specified in the 2000 FYRR. The amendment to the CCD states:

> *"Add the following language to the CCD which serves to clarify the connection between the Five-Year Review process and the remedy change process of CERCLA:*
>
> *CCD Section IV. General Requirements (Cont.) H.*
>
> *6. Normally a modification to an effluent limitation or appropriate requirement will be recommended during the Five-Year Review process described in Section IV. B. If a change to a limitation or requirement is to be implemented at another time, in accordance with the CERCLA process, it will be supported by an explanation of significant differences (ESD) or fact sheet at that time."*

The five-year update of the CCD for the LWTU was issued by EPA to Army on December 18, 2002 (EPA 2002a). This CCD update incorporated the revised Federal Water Quality Criteria detailed in the 2000 FYRR. The above-described actions taken to date have achieved the intended purpose.

5.2.6 Changes in Polychlorinated Biphenyl Decontamination Standards

The 2000 FYR concluded:

> *"The updated provisions of the Code of Federal Regulations, Title 40, Section 761.79 should be adopted within three months of the issuance date of this report."*

The Army took the following actions as a result of the 2000 FYR. The Army updated the RWMP to include changes in the PCB decontamination standards, and this plan was transmitted in Final form to the Regulatory Agencies (FWENC 2003g). The described actions taken to date have achieved the intended purpose.

5.2.7 Private Well Network

The 2000 FYR concluded:

> *"The number of off-post confined flow system wells monitored as part of the Private Well Network project should be reduced based on evidence presented in Section 7.1.3.2 of this report. The following wells should be monitored for DIMP; 1070B, 343A, 359A, 486C, 588A, 589A, 848A, and 914B. Wells 1070B and 914B should also be monitored for chloroform. This sampling should continue annually until contaminant concentrations fall below analytical reporting limits, or until the well has been sampled at least five times and the mean concentration plus two standard deviations is less than the CSRG. This new criteria for evaluating wells in the Private Well Network should be implemented via an ESD or a Fact Sheet. This ESD or Fact Sheet should be submitted for approval within three months of the issuance date of this report."*

The RVO took the following actions as a result of the 2000 FYR. An RVO letter dated March 21, 2002 transmitted a Draft Final Fact Sheet, entitled "Documentation of Non-Significant or Minor Off-Post ROD Change at RMA of the CFS Well Evaluation Criteria" (RVO 2002c). Later, a March 25, 2003 RVO letter (RVO 2003c) confirmed that, since the Regulatory Agencies had no comment and concurred with the Draft Final Fact Sheet, the Draft Final Fact Sheet was now considered a Final version. Some of the wells in the Private Well Network (Wells 343A, 486C, 588A, and 589A) were not available for sampling during the 2000-2004 time-period. These wells were either unused because the owner was hooked up to a South Adams County Water and Sanitation District water, or the well was destroyed. The above-described actions taken to date have achieved the intended purpose.

5.2.8 Documentation of CSRG Change at NWBCS

The 2000 FYR concluded:

> *"A Fact Sheet should be submitted within three months of the issuance date of this report to correct the improper inclusion of chloride, fluoride and sulfate CSRGs in Table 7.3 of the Off-Post ROD."*

The RVO took the following actions as a result of the 2000 FYR. An RVO letter dated March 21, 2002 transmitted a Draft Final Fact Sheet, entitled "Documentation of Non-Significant or Minor Off-Post ROD Change at RMA of the CSRG for the NWBCS" (RVO 2002d). A March 25, 2003 RVO letter (RVO 2003d) confirmed that, since the Regulatory Agencies had no comment and concurred with the Draft Final Fact Sheet, the Draft Final Fact

Sheet was now considered a Final version. The above-described actions taken to date have achieved the intended purpose.

6.0 FIVE-YEAR REVIEW PROCESS

6.1 General

The RMA FYR was conducted by the Army in accordance with Paragraph 36.3 of the FFA and CERCLA, Section 121(c). The following individuals participated in the review:

- Scott Ache, PMC Environmental Compliance
- Denise Arthur, ESCO Associates.
- John Balzer, RMA Safety Office
- John Bates, Army Chemist
- Rick Beardslee, RMA, Remedy Execution, Team Leader
- Gary Brewer, IPA
- Jim Bush, PWT
- Kelly Cable, RMA, Remedy Execution
- Bob Charles, RMA, Water Group
- Leo Chen, RMA Remedy Execution
- Dan Collins, TCHD
- Larry Decet, RMA EC
- Laura DiNorcia RMCI
- John Edrich, PMC Air Group
- MAJ Wes Erickson, RMA, Chief Counsel
- Neville Gaggiani, U.S. Geological Survey (USGS) (RMA)
- John Gordon, USGS (Water Group)
- James Green, RMA Remedy Execution
- Lou Greer, RMA, Remedy Execution
- Janie Griffin, RMA Quality Group
- Lorri Harper, RMA Remedy Execution
- Brian Hvalacek, TCHD
- Tom Jackson, USFWS
- Tom James, RMA, Remedy Execution
- Ellen Kaastrup, PMC
- Mark Kearns, RMA, Project Controls
- Tim Kilgannon, RMA, Remedy Execution (Special Projects)
- Rick Kinshella, TCHD
- Scott Klingensmith, RMA Risk Assessor
- Tony LaChance, RMA, Remedy Execution
- Joelle Lipski-Rockwood, MGA, Community Involvement
- Carl Mackey, RMA, Remedy Execution

- Barbara Nabors, CDPHE
- Catherine Roberts, EPA
- Don Schild, USGS, Water Group
- John Schmuck, PMC Environmental Compliance
- Steve Singer, PWT
- Sherry Skipper, USFWS
- Cecil Slaughter, USGS, Water Group
- Lee Snowhite, PMC Environmental Compliance
- Phil Stark, PWT
- John Stetson, PWT
- Douglas Stevenson, PMC Chemist
- Levi Todd, CEI
- Susan Ulrich, RMCI, Community Involvement
- Ken Vogler, CDPHE
- Laura Williams, EPA

This 2005 FYR included a review of documents. See Section 6.3 for documents considered important to the outcome, and Section 12 for a complete list of references.

Volume 1 of this FYRR addresses only significant inspection findings that have the potential to affect the protectiveness of the remedy that were identified during the FYR inspections. These findings are reported in Section 8.0 of this report. Other less significant inspection findings that are identified in Volume II of this FYRR will be acted upon by the Army or RVO during normal housekeeping and O&M of the remedy components that have inspection findings identified during the FYR.

As appropriate, specific documents were summarized in this review to illustrate the basis for conclusions of the FYR. On-site personnel responsible for all aspects of the remedy implementation were involved in developing the 2005 FYRR.

6.2 Community Involvement and Public Notification

Community involvement was encouraged throughout the FYR process. The Army, Shell, USFWS, EPA, CDPHE, and TCHD all agreed that an inclusive FYR process would best serve the interests of the public and all involved parties. Initial public notification of the upcoming review began in fall 2004 with RMA publishing information in its community newsletter, *Milestones*, about the FYR process. The next edition, winter 2005, solicited public input about past, current and future projects and programs, as well as overall site impressions. *Milestones* is mailed to more than 50,000 residents in the Brighton, Commerce City and Montbello communities and is posted on the RMA Web site.

To encourage and gather early public participation in this process, presentations were given to the Restoration Advisory Board, the Site Specific Advisory Board, Commerce City Business and Professionals Association, Citizen's Improvement Advisory Committee and the USFWS volunteers prior to the public comment period. Members of these organizations were encouraged to provide input, concerns or issues to be addressed during the FYR. Information about the review was also posted on the RMA Web site, which included the 2000 FYR document, a fact sheet about the upcoming review, a process timeline and the ability to submit electronic comments.

Notices officially announcing the public comment period and soliciting public input were printed in the *Denver Post, Rocky Mountain News, Commerce City Beacon and Commerce City Gateway*. The public comment period began March 31, 2005 and ended April 29, 2005. Comments received during this period are included in Appendix A.

The draft final of this report was issued for public comment on April 20, 2007 and was made available to the public on the RMA Web site and at the RMA Joint Administrative Records and Document Facility, located at RMA in Building 129. Public notices officially announcing the 30 day public comment period were printed in the *Denver Post, Rocky Mountain News, Commerce City Beacon, Brighton Blade* and *Commerce City Gateway*. In addition, a presentation on the report's findings is planned for the Restoration Advisory Board and Site Specific Advisory Board. Comments received will be reviewed and considered before finalizing the document. Upon completion and issuance of the final report, a formal public notification will be made. This will include a formal public notice that the FYR process has been completed. It will also provide details on where to obtain a copy of the report. The final report, along with a summary detailing major findings and recommendations, will be available on the RMA Web site and at the RMA Joint Administrative Records and Document Facility.

6.3 Documentation Reviewed

A wide variety of documentation was reviewed while preparing this FYRR. A complete list of references is available at Section 12. The following documents were prepared during the FYRR or during efforts to respond to Regulatory Agency comments on the FYRR and are important to the outcome:

- *Denver Front Range Study Dioxin in Surface Soil, Study 2: Characterization of Dioxins, Furans, and PCBs in Random Soil Samples Collected from the Rocky Mountain Arsenal" (EPA 2001b) and "Denver Front Range Study Dioxins in Surface Soil, Study 1: Characterization of Dioxins, Furans and PCBs in Soil Samples Collected from Denver Front Range (EPA 2001c).*
- *Assessment of Residual Ecological Risk and Risk Management Recommendations at the RMA, Part I: Terrestrial Pathways and Receptors (BAS 2002, BAS 2003a).*
- *Assessment of Residual Ecological Risk and Risk Management Recommendations at the RMA, Part II: Aquatic Pathways and Receptors (BAS 2003b).*
- *Final Report, Geophysical Screening Activities and Results (SCA 1998)*
- *DIMP Investigation (RVO 2002a)*
- *Unbackfilled Human Health Exceedance Characterization (*USFWS 2002a*)*
- *Former Chemical Sewer Section 26 and 35 Data Review and Summary Report (FWENC 2000k)*

- *Secondary Basins Soil Remediation Project and Section 35 Soil Remediation Project Data Summary Report (FWENC 2001h)*
- *RMA Interim Institutional Control Plan (PMRMA 2006a)*
- *Vegetation Management Plan (TTECI 2006h)*
- *ROD Amendment for Section 36 Lime Basins and Former Basin F Principal Threat Soil (TTECI 2005a)*

These reports are discussed in the following subsections.

6.3.1 Dioxin Study

The EPA, in conjunction with CDPHE and RMA, prepared several studies to characterize dioxins at RMA on a site-wide basis through a random sampling program on each of the 28 sections of land (EPA 2001b, 2001c). These studies determined that the concentration of dioxins is low in most samples of soil collected from random locations at RMA. The test results indicated dioxin concentration values similar to those observed in open space and agricultural areas within the Denver Front Range area. These surficial soil dioxin concentrations do not pose a significant health risk.

6.3.2 Terrestrial Biota Residual Risk Evaluation

The selected remedy in the On-Post ROD for the Additional Component addressing monitoring of potential risk to biota requires:

> *"Continued monitoring, as part of design refinement, for areas that may pose a potential risk to biota as outlined in the following process:*
>
> - *The BAS of technical experts (such as ecotoxicologists, biologists, and range/reclamation specialists) from the Parties will focus on the planning and conduct of both the USFWS biomonitoring programs and the SFS/risk assessment process. The BAS will provide interpretation of results and recommendations for design refinements to the Parties' decision makers.*
> - *The ongoing USFWS biomonitoring programs and the SFS/risk assessment process was used to refine design boundaries for surficial soil and aquatic contamination to be remediated.*
>   - *Phase I and the potential Phase II of the SFS will be used to refine the general areas of surficial soil contamination concern. The field biomagnification factors will be used to quantify ecological risks in the Area of Dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of excess risks.*
>   - *Pursuant to the FFA process, USFWS will conduct detailed site-specific exposure studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC report as appropriate). These studies will address both the aquatic resources and at least the surficial soil in and around the Area of Dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.*

- *Results from both the SFS/risk assessment process and the site-specific studies will be considered in risk-management decisions, which may further refine the areas of surficial soil and aquatic contamination to be remediated. (In the event of a conflict between management of RMA as a wildlife refuge and performance of remedial response actions, the Rocky Mountain Arsenal National Wildlife Refuge Act indicates that response actions will take priority.)*

- *The BAS will serve as a technical resource to the Parties' decision makers by using technical expertise in analyzing, and potentially collecting, data sufficient to support design refinement for surficial soil areas and aquatic resources that will break unacceptable exposure pathways in consideration of minimizing habitat disturbance. Further, it will assess through monitoring the efficacy of remedies in breaking unacceptable pathways to biota. If any additional sites are identified, the remedy will be implemented as follows:*
  - *It will be staged to allow habitat recovery.*
  - *It will be performed first on locations selected through a balance of factors such as:*
    - *The Parties agree an area has a negative impact on or excessive risk to fish or wildlife.*
    - *The effort will not be negated by recontamination from other remediation activities.*
    - *The existing fish and wildlife resource value.*
  - *It will include revegetation of a type specified by USFWS; if the initial revegetation is not successful, the appropriate adjustments will be made and revegetation again implemented.*
  - *It will provide that the locations and timing of remediation are to be determined with consideration of and in coordination with USFWS refuge management plans and activities.*
- *The SFS, biomonitoring programs, and recommendations of the BAS will be used to refine the areas of remediation during remedial design."*

To better assess residual risk, the BAS used results of the Supplemental Field Study Phase 1 (FWENC 1996b) to narrow its focus and resolve uncertainties in the Integrated Endangerment Assessment/Risk Characterization estimates (Ebasco 1994). The Supplemental Field Study indicated that while risks to mammals were overestimated in the Integrated Endangerment Assessment/Risk Characterization, risks to small birds were underestimated. Small birds are the most sensitive ecological receptor at RMA and were used as the indicator species to insure that all other terrestrial receptors would be adequately protected. The Supplemental Field Study results also indicated that approximately 90 percent of the risk to the small bird receptor was caused by exposure to combined aldrin and dieldrin, termed todrin (total for "aldrin and dieldrin"). Thus, further refinements to the risk assessment model were made using the small bird exposure to todrin data.

Based on additional surficial soil sampling results and ecological risk modeling, the BAS estimated residual risks for surficial soil areas outside ROD-specified remediation areas and identified two regions of potential excess risk soil that were generally divided into higher and lower risk areas. The BAS, working in coordination with the Borrow Team, recognized that potential residual risk areas could be reduced if the potential excess risk soil areas coincided with planned borrow areas. The BAS recommended that the higher-risk soil be a first priority of soil used for borrow, hence this biota-risk soil was termed P1 soil. The lower-risk soil was termed P2 soil. This initial effort concluded with a BAS recommendation to the RMA Committee that the higher risk, or P1 soil sites, should have priority for surface soil (0 to 1 ft.) removal in order to further reduce areas of exposure and corresponding population risks. The RMA Committee accepted the BAS/Borrow Team recommendations to refine the projects and borrow areas sites to include P1 soils and subsequently documented this minor ROD change in an agreement titled "Design Refinement of Excavation Boundaries for Surficial Soil and Reduction of Residual Biota Risk" (PMRMA 1997b). This agreement committed to the remedy of the identified P1 soil sites (approximately 997 acres) and detailed requirements for use of the majority of this soil as borrow soil.

The BAS completed its assessment of residual terrestrial ecological risk and recommended additional risk reduction actions in the "Assessment of Residual Ecological Risk and Risk Management Recommendations at the RMA Part I: Terrestrial Pathways and Receptors" (TRER Report) (BAS 2002, BAS 2003a). Residual risks to terrestrial wildlife were estimated using the small bird receptor and exposure to aldrin and dieldrin, the main contributors to risk. The BAS evaluated risks for areas outside the ROD-defined remediation and borrow removal areas, including P2 soil sites and limited exempted soil sites under the 1997 RMA Committee Agreement. The results are represented as estimated Hazard Quotient (HQ) values, which reflect the average risk over the small bird's home range (approximately 2.88 acres). Sites with an HQ ≤ 2 and/or of insufficient acreage (<2.88 acres) are considered acceptable risk and no remedial action is necessary.

The study used a tiered approach to identify the magnitude and extent of additional risk areas. Initially, 60 sites were identified with potentially elevated residual risk to biota based on estimated soil concentrations. After additional soil sampling in 24 of the 60 sites and further evaluation, it was determined that 18 of the sites were within acceptable risk levels (i.e., HQ $\leq$ 2). There remained 42 TRER sites with potentially elevated risk (HQ > 2) that required remediation. The BAS provided recommendations for remediating these sites, including soil tilling/revegetation, which were approved by the RMA Committee and documented in an agreement titled "Refinement of Remediation Areas for Surficial Soil and Reduction of Residual Biota Risk" (PMRMA 2003e). In addition, Site 35CC-6, Rattlesnake Hill, was identified for further biomonitoring to assess risk potential.

In accordance with the Committee Agreement, a Tilling Demonstration Study was performed with an objective to confirm, through soil samples collected, that concentrations of OCPs were at or below an HQ of 2 after the sites were tilled. Seven TRER sites were selected and sampled for this study (TTFWI 2004k). A portion of one site was found to have elevated OCP concentrations derived from the nearby Sand Creek Lateral. This area was removed from the TRER site and added to the Miscellaneous Southern Tier Soil Remediation Project for remediation. Sample results confirmed ecological risks for the small bird were acceptable in all but one subplot of the remaining TRER sites selected for this study. Sample results for the one subplot had concentrations resulting in an HQ of 2.5 (BAS 2006). Based on the results of this study, all remaining unremediated TRER sites were sampled to confirm that soil OCP levels were within the effective risk reduction range ($2<HQ \leq 10$) of the tilling process. Sites tilled prior to the Soil Tilling Demonstration Study were also sampled to confirm that HQs for these sites have been reduced to an HQ of 2 or less. In addition, P1 soil in Borrow Area 9C was sampled to determine actual risk. The results are documented in the Borrow Areas Management Data Summary Report for Residual Ecological Risk Sites (TTECI 2006h) and the Terrestrial Residual Ecological Risk Soil Tilling Demonstration Study Report (BAS 2006a).

Identification of these Residual Ecological Risk (RER) sites (both P1 soil and TRER areas) for remediation was completed in accordance with the process described in the ROD. Designation of these RER sites resulted in completion of the ROD-identified requirements for the BAS. Future terrestrial and aquatic biomonitoring for the USFWS Refuge Biomonitoring Program will be evaluated as part of the CERCLA FYR process in Section 7.2.3.5.

In addition to the 42 TRER sites, one additional site, 35CC-6 (Rattlesnake Hill), was identified with potential residual risk to biota. The assessment of 35CC-6 in the RER CCR (TTECI 2006i) indicated that residual risk was already at an acceptable level; however, due to elevated tissue concentrations at the site, 35CC-6 was identified as requiring additional biomonitoring. Biomonitoring data collected in 2003 from starling nest boxes in the area showed detectable levels of aldrin/dieldrin; however, concentrations were well below established literature values for a No-Observable-Effect-Level. These data indicate that there may still be a minor open exposure pathway near or on Rattlesnake Hill. This observation is consistent with the recent discovery of contamination remaining along the banks of the Sand Creek Lateral, which runs through Section 35 near Rattlesnake Hill. These soils were removed in 2006. However, even with the presence of these soils, the exposure to small birds at Rattlesnake Hill is currently low and no significant adverse impacts on small bird populations are expected now or in the future. Therefore, the previous acceptable risk estimates are supported by the 2003 biomonitoring data. Based on the latest biomonitoring data, the current marginal risks to small birds are outweighed by the unique habitat values on Rattlesnake Hill and no further remedy action is required. Rattlesnake Hill will continue to be included in the Refuge's long-term biomonitoring plan conducted by the USFWS.

6.3.3 Aquatic Residual Risk Assessment

Section 9.4 of the ROD required that the ongoing USFWS biomonitoring programs and the Supplemental Field Study and risk assessment process be used to refine remediation design boundaries for aquatic contamination. To satisfy this requirement, the BAS identified the most current data collected after the publication of the Integrated Endangerment Assessment/Risk Characterization in 1994 and conducted a revised risk assessment for the South Lakes. As part of this evaluation, all of the exposure assumptions and toxicity reference values used in the Integrated Endangerment Assessment/Risk Characterization were reviewed and some were revised based on current EPA guidance. The Assessment of Residual Ecological Risk and Risk Management Recommendations at the RMA, Part II: Aquatic Pathways and Receptors (BAS 2003b) estimated risks for the great blue heron, shorebird and waterbird. This evaluation concluded there are no significant risks to aquatic birds in the South Lakes that require additional remediation beyond that already defined in the ROD. Long-term aquatic biomonitoring will be performed as part of the USFWS Aquatic Biomonitoring Program.

6.3.4 Geophysical Screening Activities and Results

Sanford Cohen and Associates (SCA 1998) performed a geophysical survey at RMA in 1998 covering an area of 3,240 acres, with 10,693 anomalies detected in Sections 2, 4, 6, 19, 20, 25, 29, 30, 31, 32, 35 and 36. The survey was conducted to facilitate nonintrusive geophysical screening for subsurface targets using arrays of total field magnetometers positioned using global positioning system navigation technology.

Subsequent to that study and based on site histories, the 7,727 target anomalies resulting from the SCA geophysical survey, which was located in Sections 19, 20, 25, 29, 30 and 32 were analyzed. Each of the target anomalies was analyzed, identified, and characterized using seven different parameters which eventually led to the excavation/characterization of 783 targets. Of these 783 targets, two resulted in MEC; both targets resulting in MEC were located within the boundary of Site ESA-4a. The remaining 781 targets resulted in munitions debris, cultural debris, or were geologic-related (FWENC 1999c). The primary objective of the anomaly characterization effort was to determine the extent of the areas which would require an additional munitions response effort. This information was used to ensure the safe implementation of remedy projects completed in those areas.

6.3.5 DIMP Investigation at the Hazardous Waste Landfill

In 2001, DIMP was unexpectedly detected in the leak detection water of Cell 2 of the HWL. After confirmation over several sampling events, an investigation was undertaken to confirm that the primary liner of the HWL has not been compromised, to evaluate the source of the DIMP and to avoid use of DIMP-contaminated materials during ELF construction (RVO 2002a).

First, the absence of DIMP in samples from the leachate collection system allowed the investigators to quickly confirm that the primary liner for the HWL had not been compromised and that leakage of leachate from the leachate collection system into the leak detection layer could be ruled out as the source of contamination.

Second, the team identified three sources or pathways of contamination:

- Large volumes of South Lakes water or infiltrated groundwater delivered through the nonpotable water supply and used to condition clay in the primary liner
- Borrow Area 5 clay used for the primary liner that was underlain by a DIMP groundwater plume
- Sanitary Sewer line traversing Borrow Area 5 and acting as a conduit from DIMP contamination originating in the North Plants vicinity

Each of these possible sources was evaluated using both existing and newly collected analytical data and available empirical evidence. As a result, the sanitary sewer line traversing Borrow Area 5 was determined to be the most likely source and pathway for the DIMP identified in the HWL leak detection system.

This conclusion allowed the RVO to modify its approach to ELF liner construction in two ways. First, the portion of Borrow Area 5 delineated for liner construction is located a minimum of 50 ft. from any pre-existing sanitary sewer alignment. Second, although only a very remote possibility, the depth of excavation for borrow materials would maintain a minimum distance of 10 ft. from the historic high groundwater table.

6.3.6 Unbackfilled Human Health Exceedance Soil Characterization

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. However, approved designs for Miscellaneous Northern Tier Soils (NCSA-8b), Miscellaneous Southern Tier Soils (SSA-2b and WSA-6a), Lake Sediments Remediation (SSA-1b), ESL Section 4 (WSA-2) and ESL Section 1 (SSA-4) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. However, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

Sites SSA-2b and WSA-6a were not sampled because these ditch sites were regraded following excavation and the areas were small compared to the small bird exposure range. The BAS evaluated WSA-2 and determined, because of its size, the site did not pose excessive risk to biota (USFWS 2002a).

At the recommendation of the BAS, NCSA-8b, SSA-1b and SSA-4 were resampled using an analytical method capable of detecting concentrations of COCs in the biota risk range (USFWS 2002a). Sampling was performed consistent with the method developed by the BAS for the TRER evaluation by collecting a 5-point composite sample over each area representing a small bird exposure range. The sampling at Site SSA-1b showed no excessive risk to biota. The additional sampling indicated that there was contamination remaining at the excavation surface in sites NCSA-8b and SSA-4. Both NCSA-8b and SSA-4 were excavated, resampled, determined to not show excessive risk and documented in addenda to the project CCRs.

6.3.7 Chemical Sewer Sampling in Sections 26 and 35

The ROD required that sewer lines and HHE soil for chemical sewers (NCSA-6a) located in Sections 26 and 35 be excavated and landfilled in the on-site HWL. During design, it became apparent that a large portion of the sewer and associated soils had already been removed as part of the 1982 sewer response action. Subsequent sampling during the RI indicated that the removal of the chemical sewer line and associated soils eliminated the vast majority of the contamination. As a result, the RVO proposed to modify the remedy and not remove additional soil at the location of the former chemical sewer site. In response to a request from EPA and CDPHE to verify that no HHE soil remained, additional sampling was performed and documented in the Former Chemical Sewer Sections 26 and 35 Data Review and Summary Report (FWENC 2000k). A total of 41 samples were collected and analyzed. When combined with the RI sampling, the 110 samples showed no evidence of soil contamination in excess of human health criteria. These data were used as the basis for an ESD (FWENC 2000i) to eliminate the requirement for additional soil removal from Site NCSA-6a in Sections 26 and 35 Secondary Basins Soil Sampling.

6.3.8 Secondary Basins Soil Sampling

The secondary basins were previously characterized during the RI. A summary of the information collected during the RI can be found in the Remedial Investigation Summary Report (Ebasco 1992) and in the Detailed Analysis of Alternatives Report (FWENC 1995). Risk-based analysis of the data collected resulted in designation of HHE and biota soils in Basins B, C and D. As part of the secondary basins remediation, the ROD required excavation and landfilling of HHE soils and construction of a 2-ft.-thick soil cover over the entire area of Basins B, C, and D, including the biota risk areas. During design, a modification to the ROD remedy was proposed to remove all contaminated soil and to eliminate the need for soil covers over the basins.

To support the proposed modification, additional soil sampling was performed. Sampling and analysis was performed throughout the basins to ensure that the resultant soil surface following excavation does not contain concentrations of COCs that exceed HHE criteria. Additional sampling and analysis was performed from 10 ft. to groundwater to determine whether there was additional soil that could potentially contaminate groundwater. The resulting sampling effort required collection of 224 samples at 112 locations throughout the three basins. A review of the results indicated that there were no samples exceeding HHE criteria and no detections of VOCs, DIMP, dithiane or NDMA (FWENC 2001h). This sampling effort, when combined with the RI results, provided a total data set of more than 1,600 samples in the three-basin area.

6.3.9 Interim Institutional Control Plan

The RMA FFA (EPA 1989) established institutional controls restricting the current and future use of real property and resources within the RMA boundaries. The institutional controls identified in the FFA are also required by the ROD for the On-Post OU. These primary institutional controls prohibit residential development, use of ground or surface water as potable, consumption of fish and game, agricultural activities (except those required for remedial actions or erosion control) and major alteration of the hydrogeologic characteristics of RMA. The FFA institutional controls also require preservation and management of wildlife habitat to protect endangered species, migratory birds, and bald eagles. Additionally, in accordance with the February 3, 1993 letter from Lewis D. Walker (Walker 1993) the Army and the USFWS will neither build, use, or allow use of any basements at RMA unless the Army or USFWS prepares a feasibility study a that addresses the impact of the use of basements on human health and the environment, and substantiates that such impacts are minimal.

During preparation of and resolution of comments on the 2005 FYRR, the Interim Rocky Mountain Arsenal Institutional Control Plan was revised (PMRMA 2006a). The original and the revised plan provide the framework for ensuring that workers and visitors at RMA are safe and that facilities are protected. The Rocky Mountain Arsenal National Wildlife Refuge Public Use Plan (USFWS 2004) identifies the access controls used by the USFWS in implementing Public Use programs at the Refuge.

The Army continues to use a multi-tiered access and control program that governs all site activities. A perimeter fence restricts unauthorized access. The west fence was relocated in 2004 when the Western Tier Parcel was acquired by Commerce City. Controlled access points (west, south and north gates) limit access to those people having proper identification and legitimate business at RMA. Access to the Central Remediation Area, where the cleanup is in progress, is restricted to workers having a Central Remediation Area badge or visitors who are escorted by Central Remediation Area-badged workers. Access to individual project sites is limited to those Central Remediation Area-badged workers who have the proper training, health monitoring and prescribed PPE required for that site. Signs throughout the site identify boundaries of restricted areas and provide access restrictions. Signs are removed or relocated as necessary as restricted area boundaries change.

RMA activities are managed and monitored through a centralized database called Safe RMA Access and Control. All proposed major actions involving people and equipment on the ground must be entered into Safe RMA Access and Control and approved in advance. Visitor tours are also required to provide a Safe RMA Access and Control submittal and obtain approval prior to the tour.

The Interim Rocky Mountain Arsenal Institutional Control Plan also lists other areas that require additional institutional controls. These provide specific limitations commensurate with the risk presented by the area or the feature being protected. Included are additional institutional controls for the previously excavated lake sediments (SSA-3b), for the Lower Derby Lake sediments, for the buffer area around the Basin F Wastepile during remediation, for the covers; for groundwater remedy structures and for lake level maintenance.

Areas of RMA where property and management authority have been transferred to the USFWS are governed by National Wildlife Refuge System regulations in Title 50, Subchapter C of the CFR. These regulations provide the USFWS with the authority to manage the entire National Wildlife Refuge System, including the Refuge. These regulations also close all areas of RMA included in the National Wildlife Refuge System to the public unless these areas are opened by regulation, individual permit or public notice.

The USFWS Rocky Mountain Arsenal National Wildlife Refuge Public Use Plan identifies access controls that are used by the USFWS for both weekday and weekend visitor programs. On weekdays, vehicle passes that must be displayed in the windshield are issued to Public Use visitors at the south gate, and visitors are directed to the Visitor Center. On weekends, C Street is gated immediately north of the Visitor Center driveway to prevent visitors from accessing unauthorized areas. Weekday programs are suspended if necessary to ensure that remedial activities do not impact visitors.

Access restrictions and institutional controls have been implemented and revised as necessary. They have effectively prevented individuals from exposure to unacceptable levels of risk. Two unauthorized outside individuals crossed the Central Remediation Area boundary and entered exclusion zones. The first individual was being pursued by Commerce City police at 1:20 AM. He drove his Buick into the North Plants Chemical Sewer (NCSA-6b) excavation, after driving through the west fence near 64th and Quebec, along the perimeter road to 7th Avenue, and through Central Remediation Area access and project site controls. The suspect was taken into custody and the vehicle was decontaminated prior to removal from RMA. The second individual was hiking across RMA to get to Wal-Mart. He was observed approaching the exclusion zone of an anomaly target characterization area in Section 36. He was stopped by PMC UXO personnel when he entered the exclusion zone. PMC personnel escorted him from the exclusion area and notified RMA police.

6.3.10 Vegetation Management Plan

There are two slightly different circumstances for revegetation at RMA. The first type of area is that involving between 600 and 700 acres of landfill caps and other final soil covers for consolidation sites. In these locations, the vegetation plays a role in the remedy by transpiring stored soil moisture as well as providing erosion protection. The type of vegetation suitable for these sites is initially limited to grass species sustainable at these locations. These constructed covers are subject to agreed-upon performance criteria for vegetation diversity, growth and sustainability.

Vegetation diversity is not restricted at any other non-cap/cover areas of habitat improvement, including remedy areas not employing a cover system, as well as other poor quality habitat sites. Assessment of these sites is conducted by the USFWS.

The principles that guide the seeding efforts at RMA are set forth in the Comprehensive Management Plan for the site (USFWS 1996a). One of the six goals for the site set forth in the Comprehensive Management Plan is the following:

> "Manage wildlife and habitat to contribute to ecosystem management using strategies that recognize the Refuge's different resource types and the varying purposes specified in the enabling legislation."

Management principles used to guide programs with the objective of achieving this goal include the following:

1. Management and restoration of habitat for indigenous species
2. Preservation and establishment of native plants and animals to encourage self-sustainable systems

The Habitat Restoration Plan (USFWS 1999a) provides the framework for revegetation at the site. This document is a step-down plan based on the goals identified in the Comprehensive Management Plan. Objectives for the Habitat Restoration Plan include the following:

1. Avoidance or minimization of wildlife habitat damage during cleanup
2. Replacement of wildlife habitat damaged during production and cleanup
3. Restoration of native plant communities
4. Development of stable vegetation communities for specific native wildlife
5. Maintenance of existing plant communities

The Terrestrial Revegetation Program has been developed to implement the goals of the Comprehensive Management Plan and the Habitat Restoration Plan. Over the course of remedy implementation, about 8000 acres of land disturbed during construction of remedy projects and other poor quality habitat will be seeded with native plant species with the goal of establishing high quality prairie grasslands. Annually, approximately 750 acres are identified for seeding, irrigation for seedling establishment and maintenance. This program began development as early as 1988 when initial habitat improvement projects were conducted. A more formal program was developed by the USFWS in 1991 and has been supported by the RVO since 1996.

Detailed specifications direct the revegetation program. The basic approach includes the following:

- Weed control in areas with a weedy history
- Addition of compost to subsoil in borrow areas where topsoil has been removed or cover areas where subsoil has been used to construct the surface soil layer
- Preparation of soil to provide a smooth surface appropriate for seeding of the native seed mixes
- Seeding native seed mixes to establish self-sustaining prairie habitat
- Applying native grass hay mulch to the seeded areas to stabilize soil, as well as provide other benefits during seedling establishment
- Irrigation of seeded areas for the initial growing season to support seedling establishment and growth
- Maintenance of seeded areas to control weed competition and encourage development of prairie habitat

By the summer of 2005, approximately 4,536 acres have been seeded at RMA for habitat improvement and restoration through a variety of programs. Through applying success criteria developed by USFWS, 38 percent of these acres have been judged successful, and 49 percent are considered nearly successful, but require additional development time and/or maintenance activity. Only 11 percent or approximately 571 acres have failed the applied success criteria. Although these areas will likely require reseeding, the approach to habitat restoration has been improved through the lessons learned from these seeding activities. Possibly the primary lesson learned is the requirement for adequate control of weeds prior to seeding the native mix. Adequate depletion of the soil weed seed/propagule bank can take several years of prior weed control to enable successful establishment of native grasslands in an acceptable time frame.

The HWL/ELF cap, the RCRA-equivalent covers and the 2- and 3-ft. cover areas have a unique set of plant community success criteria because establishment of prairie-like plant communities is essential for the required self-sustaining erosion protection and annual surface soil drying through evapotranspiration. Future FYRs will assess vegetation at these sites.

During preparation of and resolution of comments on the 2005 FYRR, an ESD was prepared (TTECI 2006a). The ROD soil remedy requires that all sites disturbed during remediation shall have the surface soil reconditioned and be revegetated with locally adapted perennial vegetation. Remedy and support areas completed to date have been revegetated with either temporary or permanent vegetation, and/or have been identified for seeding in accordance with the Habitat Restoration Plan and the annual Vegetation Management Plan (TTECI 2006j). All revegetated areas were assessed in the June 2005 FYRR inspections.

In recognition of the unique status of RMA in which the Refuge Act requires most of the RMA to be transferred to USFWS upon completion of the remedy, the revegetation requirement was clarified by the ESD. As a result, remedy sites located on property that will be transferred to the USFWS will be reconditioned and seeded in a manner acceptable to the USFWS. Revegetation remains the responsibility of the Army; however, responsibility for acceptance of revegetation performance and function after seeding will be independently conducted by the USFWS for the non-cover future refuge areas.

Specifically the ESD provides:

> *"Sites will be reconditioned and seeded in a manner acceptable to the USFWS consistent with the USFWS management plan and annual "Vegetation Management Plan". For areas disturbed during the remedy, the USFWS will certify, in writing, to the EPA that the site has been revegetated or has a USFWS-approved revegetation plan that is being implemented, and that the USFWS is satisfied that the site's habitat is being or will be restored to achieve the statutory purposes of the Refuge."*

As a result of the ESD, on June 29, 2006, in a letter to EPA (USFWS 2006a) the USFWS certified: that Site BT-32-10 was complete and satisfied the statutory purposes of the Refuge, that Site ESA-4a has a USFWS-approved revegetation plan, and that the current status of both sites is included in the Vegetation Management Plan (TTECI 2006j). In addition, the USFWS noted that "responsibility for the assessment and acceptance of the noted parcels will be reflected in future versions of the Vegetation Management Plan."

6.3.11 ROD Amendment for Section 36 Lime Basins and Former Basin F Principal Threat Soil

The remedy outlined in the On-Post ROD for the Lime Basins included excavation of principal threat and HHE soil with disposal in the ELF. During the remedial design for the Lime Basins, which began in 2002, new information was developed and it became apparent that actual conditions at the Lime Basins differed significantly from those discussed in the ROD. In particular, the remediation volume to be placed in the ELF and short-term risks associated with the excavation had increased significantly. These significant changes also resulted in a cost increase compared to the ROD estimate.

Consideration of the changes encountered and associated cost increases resulted in a determination to reevaluate the remedial action for the Lime Basins project. In accordance with the FFA, the Army proposed a change to the RMA Committee for the Lime Basins remedy that included containment in place rather than excavation and landfill. As discussions progressed for reevaluation of the Lime Basins remedy, the possibility of not excavating the Lime Basins presented a potential opportunity to use a portion of the landfill space in the ELF for containment of waste from the remaining projects. The remaining soil projects to be implemented at RMA were reviewed to determine whether they were compatible with the design for containment within the ELF. The evaluation criteria included identifying an area of contamination not already slated for excavation and landfill, checking that the contaminated soil was consistent with the type of contamination used in the ELF compatibility studies, and that it consisted of a volume suitable for the design capacity of the ELF. This review resulted in identification of the Basin F principal threat soil for possible disposal in the ELF

The remedy outlined in the On-Post ROD for the Basin F principal threat soil was in situ solidification/stabilization of the PT soil to a depth of 10 ft. Before any change to the remedy could be considered, a reevaluation of remedial actions for the Lime Basins and Basin F principal threat soil projects was necessary to ensure that the overall remedy remained protective. A Summary of Remedial Alternatives (TTFWI 2005a) was prepared to evaluate and compare ROD and alternate remedy options for the two projects. As a result of this evaluation, a ROD Amendment was prepared documenting new selected remedies for the Lime Basins and Basin F Principal Threat Soil projects. Evaluation of remedial alternatives included an assessment of ELF capacity to ensure that the selected remedy could be implemented with the current ELF design capacity. The ELF design included capacity for remediation waste from the Basin F Wastepile and Section 36 Lime Basins. Although the selected Basin F principal threat soil remedy includes a larger landfill volume than the original Lime Basins remedy, there is sufficient capacity for disposal of all the identified Basin F principal threat soil and the overlying and interbedded HHE soil as well as the odor control soil required.

The ROD Amendment was finalized in October 2005 (TTECI 2005a). The selected remedy for the Lime Basins is construction of a vertical groundwater barrier surrounding the Lime Basins and a RCRA-equivalent cover, including biota barrier, over the entire Lime Basins area. Dewatering wells are installed inside the barrier wall and the extracted groundwater is treated at an on-site treatment facility. The selected remedy for Basin F is excavation of principal threat soil with disposal in the on-site ELF. Excavation of principal threat soil is completed to a maximum depth of 10 ft. from the IRA final excavation surface. Following excavation of principal threat soil, the residual contaminated soil in Basin F is contained in place beneath the ROD-required RCRA-equivalent cover as part of the Basin F/Basin F Exterior Soil Remediation Project.

6.3.12 Cost

The original estimate for the remediation of RMA was 2.2 billion dollars in FY 1995 dollars. This total included approximately $750 million dollars of cost that was incurred prior to the signing of the ROD; this total also included an estimated $91million dollars in post-remedy long-term monitoring/maintenance costs. The remaining $1.364 billion dollars represents the baseline remediation-only estimate in FY1995 dollars. The escalated estimate for this scope of activity, as shown in the RMA 1997 Report to the U.S. Senate Appropriations Committee, is $1.512 billion dollars. As of March 31, 2005, RMA current escalated estimated final remediation cost was equal to the $1.512 billion dollars in the 1997 report. Of that total, $853.6 million dollars had been recorded as actual cost-to-date. Remediation at the RMA is estimated to be 56.4% complete with 56.4% of the estimated budget consumed.

6.4 Data Review

6.4.1 Groundwater

On-post and off-post groundwater monitoring programs not directly associated with the containment and treatment systems were evaluated by comparing site-wide monitoring results during the period FY2000 thru FY2005 with the 1994 baseline year, the last major sampling event at RMA prior to the issuance of the RODs, and with data from the first FYR review period. During this second FYR period, monitoring was conducted in accordance with the LTMP

(FWENC 1999a) and the Well Retention and Closure Program updates (FWENC 2003a, TTFWI 2004l).

The data evaluation in this section is presented for each of the monitoring categories and does not address monitoring associated with the groundwater containment and treatment systems discussed in Section 4.1.2.3.

Water Level Tracking: Water level monitoring is used to track the effects of the remedy in the On-Post and Off-Post OUs. Water level tracking wells will be used to monitor water levels and track flowpaths between individual on-post remedies and the RMA boundary, as well as off post. Water level tracking will be performed annually.

Water Quality Tracking: Water quality tracking of indicator compounds is conducted in selected wells either annually or twice during each FYR period to track plume migration upgradient from the groundwater containment and intercept systems. These data are collected to evaluate long-term trends in the FYRR.

Exceedance Monitoring: Off-post water quality monitoring is conducted in compliance with the Off-Post ROD to create plume maps for contaminants that exceed CSRGs. The plume maps are provided to the SEO and to Commerce City, Brighton, and Adams County officials for their use in issuing well permits and notifications and controlling inappropriate use of off-post water with contaminant levels exceeding CSRGs.

Confined Flow System Monitoring: Monitoring in response to the On-Post ROD requirement to continue to monitor water quality in the confined aquifer is conducted in three areas—Basin A, South Plants, and Basin F.

The review was conducted in accordance with the following criteria outlined in the LTMP:

- Water level tracking will be conducted annually and summarized in the FYRR. The main purpose of the long-term monitoring program is to track changes in water levels and flowpaths. A report will therefore be generated to include comparisons of new water level maps with baseline water level maps for each FYR period.
- Exceedance monitoring has separate reporting requirements in addition to its inclusion in the 5-Year Site Review. Summaries of trends based on the exceedance mapping and the most recent exceedance maps will be presented in the FYRR.
- Confined Flow System monitoring will be summarized in the FYRR, which will include an evaluation of any potential contaminant trends during that FYR period.

Conclusions from the site-wide data for these monitoring categories were used to evaluate project-specific impacts on groundwater. The conclusions of the on-post and off-post groundwater monitoring programs are summarized below.

6.4.1.1 Water Level Tracking

During the second FYR period, water level tracking was conducted in accordance with the LTMP objectives. Several soil remedies were completed during the second FYR period and their impact on groundwater was evaluated.

The On-Post ROD identified five plume groups consisting of 15 contaminant plumes on-post. The on-post plume groups that were included in the water level tracking during the past FYR period are as follows:

- North Boundary Plume Group upgradient of NBCS
- Northwest Boundary Plume Group upgradient of the NWBCS
- Western Plume Group upgradient of ICS
- Basin A Plume Group upgradient of BANCS
- South Plants Plume Group which includes plumes emanating in the South Plants Central Processing Area.

Sources and remedy areas addressed by the water level tracking program, include the following:

- Former Basin F/Basin F Wastepile
- HWL and ELF
- Basin A
- Complex (Army) Disposal Trenches and Shell Disposal Trenches
- South Plants and South Lakes

It should be noted that the water level tracking program described here addresses the site-wide remedy impacts and water level trends. Project specific details are addressed in the monitoring reports for the individual remedies that require monitoring.

The RVO collects water-level data annually during the fourth quarter (July through September) and uses the data to construct a water-table map of the RMA. The water-table map is used for identifying changes in groundwater flow directions in the unconfined groundwater that could affect contaminant plume migration. Figure 6.4.1.1-1 shows a comparison between on-post water levels in 1999 and 2004 and reflects the overall changes in water levels during the FYR period.

Remediation activities, such as groundwater extraction and recharge systems as well as the slurry wall caps and covers affect groundwater levels in several areas. Precipitation events also affect water levels and are an important source of recharge to the shallow unconfined groundwater system at RMA. The RVO collects precipitation data from an on-site station (Met4a) along C Street, about a third of a mile north of Seventh Avenue. If precipitation data are not available at that site, the RVO collects data from another on-site station (Met1a) along Seventh Avenue in the southern portion of Section 36, about 1/3 of a mile west of E Street.

Annual precipitation data from FY 1999 through FY 2004 ranged from a high of 18.29 inches in 1999 to a low of 9.87 inches in FY 2002, as summarized in Table 6.4.1.1-1. The average annual water-year precipitation at RMA is 15.48 inches.

For this FYRR (FY 2000 through FY 2004), water-level tracking data was evaluated by comparing water-level contours year-to-year beginning with the FY 1999 (the last year of the first FYR) through FY 2004. The RVO also compared water-level contours for FY 2004 to those in FY 1999 to compare the difference in groundwater flow direction and groundwater elevations in the final year of each FYR period. Precipitation events and remediation activities have created some changes in groundwater levels at RMA in the past five years. Precipitation events at RMA generally cause a rise in water-level elevations. Lack of precipitation, such as in FY 2002, results in a lowering of the water table. Remedies, such as groundwater extraction and soil covers, have also caused water levels to decline over time. The primary effect of the lower water table is a reduction in the rate of groundwater flow at RMA. Overall, based on a year-to-year water-level comparison, the groundwater flow directions from FY 1999 through FY 2004 have not changed significantly, indicating that the direction of contaminant plume migration has not changed significantly. The FY 2004 water-level contours which are compared to those generated in FY 1999 in Figure 6.4.1.1-1 show water levels that depict similar groundwater flow directions. A more detailed evaluation of water level changes is presented below.

Water levels in the South Plants area have shown an overall decline since 1992, with fluctuations during high precipitation years. The impacts of precipitation are expected to be significantly reduced as a result of installation of soil covers and caps, with corresponding declines in water levels. The associated reduction in hydraulic gradient will significantly slow the flow of groundwater from the South Plants areas. Such effects will be assessed in future site reviews after remedy implementation. The surface water data are included in the Annual Data Summary Report produced by the USGS (USGS 2001b). The water table information for the North Plants/First Creek area is also included in the Data Summary Reports (USGS 2002, 2003, 2004b, 2005a).

The evaluation of on-post water level tracking data resulted in the following conclusions:

- There were no changes in groundwater levels or flow patterns in the areas upgradient of the containment systems that affected the effectiveness of the systems during the second FYR period.
- There have been no changes in water levels that would affect groundwater flow directions and contaminant migration toward the boundary containment systems.
- In the Basin F area upgradient from the NBCS, water levels declined and then stabilized at lower levels during the past FYR period, resulting in reduced flow toward the NBCS.
- Implementation of remedies such as the Shell Disposal Trenches and Complex (Army) Disposal Trenches slurry walls, Complex (Army) Disposal Trenches dewatering and Bedrock Ridge intercept system have caused localized changes in water levels and flow directions, but have not changed groundwater levels and flow patterns in areas upgradient and downgradient of the remedy areas. Water level tracking will continue in accordance with the LTMP during the next FYR period.

6.4.1.2 Water Quality Tracking

Water quality tracking was conducted in areas upgradient of the containment systems to supplement the water level tracking data. A well network established in the LTMP was used to monitor changes in water quality and assess the influence of the soil remedies on groundwater contaminant levels and plume migration. The water quality network is presented in Figure 6.4.1.2-1. Water quality tracking data were used to assess potential changes in water quality related to the on-post plume areas, in source areas, and in remedy areas for indicator compounds identified in the LTMP.

Table 6.4.1.2-1 provides a summary of the on-post wells included in the water quality monitoring program during the past FYR period. The table identifies the following parameters:

- Monitoring location
- Monitoring purpose(s)
- Planned monitoring frequency and actual sampling dates
- Analytes

An evaluation of the monitoring programs shows that on-post monitoring was performed in accordance with the plan, with the exceptions noted below. There are 43 wells in the On-Post water quality tracking network. These wells are sampled twice in five years for the analytes shown in Table 6.4.1.2-1 for each well. The wells are distributed throughout the on-post area mostly in the region outside of the treatment systems' operational groundwater monitoring, as shown in Figure 6.4.1.2-1. Water quality tracking wells are located in the flow path of historical contaminant plumes, both near the sources of contamination and upgradient of the treatment systems. As required by the LTMP, sampling of these wells was conducted in FY02 and FY04.

There were only a few deviations from the LTMP during this FYR period. Wells 28520 and 28522, located south of the NBCS were sampled for dieldrin in FY02 and FY04 but chloroform and DIMP were inadvertently left off the list. Well 23193, in the CFS network downgradient of Basin F, was sampled in FY02 but could not be sampled in FY04 because of a partial obstruction in the well that could not be repaired. Well 35058 was damaged by soil-tilling operations in FY04, but was repaired and later sampled in October 2004.

Additional samples were collected from some of the wells that serve other monitoring purposes (e.g., treatment-system or project-area monitoring) network. For more detail see the footnotes to Table 6.4.1.2-1.

CDPHE raised concerns based upon the CDPHE Groundwater Sample Preservation Policy (CDPHE 1998) that groundwater sample preservation procedures for VOC samples at RMA were different from those in the CDPHE policy and should be changed for consistency. In accordance with CDPHE policy, acid preservation was discontinued for VOC samples on October 1, 2001. A benefit of this change was the elimination of cross-contamination of 1,2-dichloroethane (DCA) samples caused by acid preservation, which had been noted in 2000. Since concentrations of other contaminants subject to biodegradation (especially benzene) might be affected by the lack of acid preservation, VOC samples were to be analyzed using either 7-day holding times or extraction within 7 days of the sample date instead of using 14-day holding times or extraction (RVO 2001b).

The site-wide water quality tracking results are summarized below. Concentrations of indicator contaminants in plumes upgradient of the boundary containment systems show long-term declines in concentrations for several contaminants. Chloroform and DIMP levels have declined upgradient of the NBCS, NWBCS, and OGITS. Dieldrin concentrations at these systems have been relatively stable.

In the area upgradient from the NBCS, most indicator analytes show decreasing trends since the pre-ROD baseline years of 1993 and 1994. There have been significant reductions in chloroform concentrations. For example, chloroform concentrations in Well 23095 (see Figure 6.4.1.2-1) decreased from 11,000 μg/l in 1993 to below the CSRG in 2004, and Well 23096 decreased from 5,600 in 1994 to 1,000 μg/l in 2004. Some wells show short-term increases that likely were due to changes in NBCS operations with resulting changes in upgradient flow directions. Concentrations of carbon tetrachloride in one upgradient monitoring well, Well 24094, show a slightly increasing trend (from 2.84 μg/l in 2002 to 5.46 μg/l in 2004), but this is likely also caused by changes in extraction well operations.

Three CFS wells (Wells 23161, 23200 and 24171) are monitored at the NBCS for operational purposes. Well 23200 inadvertently was not sampled for indicator analytes in 2004, but was sampled for NDMA because of previous detections in 2002. In all three wells, chloride concentrations are stable and much lower than in the overlying UFS wells, and the other indicator analytes (chloroform, 4-chlorophenylmethyl sulfoxide, dieldrin, and DIMP) were not detected. NDMA is not an indicator analyte for Well 23200, which is located on the north side of the NBCS slurry wall, but it was detected in Well 23200 in 2002 at concentrations of 0.157 μg/l and 0.188 μg/l and in 2004 at 1.2 μg/l. 1,2-dichloroethane has also been detected in Well 23200 at concentrations near the CSRG. NDMA and 1,2-dichloroethane have not been detected in an adjacent shallower UFS Denver well, Well 23138, and the alluvium contains treated recharge flow, which meets CSRGs. Additionally, the chloride concentrations are higher in the shallower zones and Well 23200 does not have an increasing chloride trend. Therefore, downward migration of 1,2-dichloroethane and NDMA seems unlikely. The well evaluation report (HLA 1994) observed that the outer casing was installed too deep to seal off the alluvium or weathered bedrock separately. Also, the presence of bentonite and grout well seals is unknown. The data do not suggest that the well is leaking, but it seems likely that a small amount of contamination was pulled downward when the well was drilled in 1981. Thus, based on these three wells it can be concluded that downward migration from the UFS to the CFS is not occurring at the NBCS.

Due to concerns about potential bypass of dieldrin at the southwest end of the NWBCS during the first FYR period, pumping rates were increased and capture of the plume was maintained. These operational changes caused the dieldrin concentrations in this area to decrease during the current FYR period, making the effectiveness of the system even more robust. For example, dieldrin concentrations in Wells 27010, 27500, and 27503 (Figure 6.4.1.2-1) decreased to be consistently below the PQL of 0.05 μg/l. Dieldrin concentrations upgradient of the main NWBCS have been relatively stable in some wells, but decreased in others. Dieldrin concentrations were stable in Wells 27025, 27037, 27082, and 27083. Dieldrin concentrations have decreased in Well 27079 from 1.08 μg/l in 1995 to 0.35 μg/l in 2004, in Well 35058 from 1.2 μg/l in 2002 to 0.397 μg/l in 2004, and in Well 34020 from 1.0 μg/l in 1995 to 0.234 μg/l in 2004.

Near Lake Mary, the dieldrin concentration in Well 03016 was relatively stable at about 0.07 μg/l, which is slightly above the PQL, and the dieldrin concentration in Well 02056 remained below the reporting limit. The results for Wells 03016 and 02056 indicate that the dieldrin plume that migrates toward the NWBCS Southwest Extension continues to migrate under Lake Mary without impacting the lake.

Although the dieldrin concentration in Well 03016 is still above the PQL, historical data indicate that the plume concentrations decrease to below the PQL downgradient of Well 03016. Dieldrin concentrations upgradient of the NWBCS Southwest Extension decreased to below the PQL during the current FYR period, such that shutdown of the NWBCS Southwest Extension extraction well system is being contemplated since dieldrin is the only contaminant present. Chloroform and DIMP concentrations upgradient of the original NWBCS continue to decline. For example, DIMP concentrations have decreased to below the CSRG in all NWBCS extraction wells, and the average chloroform concentrations in the NWBCS influent have decreased from 14 μg/l in 1991 to 2.6 μg/l in 2004.

As discussed in Section 4.1.3.2, the trichloroethylene and DBCP extraction wells in the Motor Pool and Irondale areas upgradient of the ICS achieved shut-off criteria during the past FYR period. Shut-off monitoring for both areas was completed during this FYR period. Former ICS extraction Well 33341 is sampled to monitor the trend in trichloroethylene concentrations in the Western Plume, which originates south of RMA. The trichloroethylene concentration in Well 33341 decreased to below the CBSG of 5 μg/l during the FYR period (from 7.21 μg/l in 2002 to 4.17 μg/l in 2004). The Rail Yard extraction wells continue to operate, and treatment of this plume was transferred from the ICS treatment plant to a smaller treatment facility at the Rail Yard during the current period. DBCP concentrations upgradient of the Rail Yard extraction system are declining and are approaching the CSRG. Additional monitoring is being conducted to evaluate potential shutdown of this system.

In the South Plants source area, concentrations of indicator compounds have been relatively stable or have shown significant decreases. Indicator analytes chloroform and dieldrin have been relatively stable in Well 01078. In Well 01534, benzene concentrations decreased from 830,000 μg/l in 2002 to 670,000μg/l in 2004 and chloroform was not detected. In Well 01525, chloroform levels have decreased significantly (two orders of magnitude) since 1994, and decreased one order of magnitude since 2002. The chloroform concentration in Well 01525 decreased from 1,100,000 μg/l in 1994 to 370,000 μg/l in 2002 and 12,000 μg/l in 2004. As shown in Figure 6.4.1.2-2. This decline in chloroform concentrations has coincided with a decrease in water levels where the alluvium has become unsaturated and the water table is below the top of the weathered bedrock. This concentration reduction likely is due to a combination of factors, including soil and chemical sewer remediation in South Plants, but likely is also related to the reduction in contaminant mobility caused when the groundwater level falls below the alluvium and the groundwater flow is in the less permeable bedrock. In Well 01525, indicator analyte dieldrin was relatively stable likely due to its lower solubility, but other non-indicator contaminants in Well 01525 such as benzene, chlorobenzene, trichloroethylene, and tetrachloroethylene showed significant concentration decreases.

In the South Lakes area, concentrations of indicator analytes benzene, chloroform, and dieldrin either were below the CBSG or PQL or have shown decreasing concentration trends. Benzene concentrations have remained below the CBSG in all wells monitored (i.e., Wells 02034, 02505, 02512, 02524, and 02525) and below the reporting limit in most of these wells. In 2004, benzene was detected in two of the five wells (Wells 02034 and 02524) at concentrations of 1.56 μg/l and 2.04 μg/l, respectively. Chloroform concentrations either were below the CBSG or below the reporting limit in Wells 02034, 02512, and 02524 and have decreased significantly in Wells 02505 and 02525 since the baseline year. Chloroform concentrations in Well 02505 have decreased from 63μg/l in 1993 to 17.4μg/l in 2004, and in Well 02525 decreased from 190μg/l in 2002 to 79μg/l in 2004. Dieldrin was not detected in Wells 02034, 02505 and 02525. Dieldrin was detected in two wells and concentrations decreased in Well 02512 from 0.286 μg/l in 2004 to 0.233 μg/l in 2004, and decreased in Well 02524 from 0.79 μg/l in 1999 to 0.44 μg/l in 2004. Information on the South Lakes area concentration trends were also discussed in the Lake Mary Fact Sheet (PMRMA 2003f).

In the Basin A/Basin A Neck areas, concentrations of several of the indicator analytes were below the BANCS CSRGs. Other analytes display a long-term downward trend, with some short-term increases. In Well 35065, benzene, chloroform, and DBCP concentrations were below the CSRG; however, DIMP and dieldrin concentrations increased between 2002 and 2004. DIMP concentrations increased from 600 to 1500 μg/l and dieldrin concentrations increased from 0.18 to 0.44 μg/l. Both increases are within historical ranges. No indicator analytes were detected in Wells 26500 and 35069.

Downgradient of the BANCS, NDMA concentrations have decreased since 2002 due to shutdown of the North of Basin F Extraction Well. In Well 26006, NDMA concentrations decreased from 0.273 μg/l in 2002 to 0.107 μg/l in 2004. In the same well, DIMP concentrations have decreased from 830 μg/l in 1993 to 150 μg/l in 2004. Historically, NDMA concentrations have decreased downgradient of Well 26006 to below detectable levels. Well 27025 is located downgradient of Well 26006 and NDMA was not detected in this Well 27025 during the this or the last FYR period.

In the Former Basin F area, many contaminants display an overall decreasing trend. Of particular note are significant decreases in chloroform concentrations in a few wells. Chloroform was not detected in Wells 26015, 26017, and 26163 as the plume is located farther east. Chloroform concentrations in Well 26157 decreased from 38,000 μg/l in 1999 to 7,600 μg/l in 2004. In Well 26015, DIMP concentrations have been below the CSRG since 1999. DIMP concentrations in Wells 26017, 26157, and 26163 have varied, but have remained within similar ranges since 1993/1994. In 2004, the DIMP concentrations ranged from 58 μg/l in 26017 to 1200 μg/l in 26157 and 26163. Well 26015 has shown an increasing chloride concentration trend from 1,700,000 μg/l in 2002 to 2,000,000 μg/l in 2004, but without accompanying increases in organic contaminants.

In North Plants, downgradient concentrations of chloroform in Well 25059 decreased to below the reporting limit. The DIMP concentration increased slightly from 23 μg/l in 2002 to 31μg/l in 2004. The other indicator analytes (trichloroethylene 1,2-dichloroethane, carbon tetrachloride, and dieldrin) were not detected. Fuel contamination originally discovered in North Plants Well 25055 was further delineated using temporary piezometers installed as part of the North Plants soil investigation. The free phase waste is composed of diesel range organics, that had not been quantified as of the cutoff date for the FYRR. The fuel contamination discovery is further discussed in Section 4.4.2.4

Upgradient of North Plants and downgradient of the Bedrock Ridge System, three water quality tracking wells are monitored. Indicator analytes in Wells 25502, 25503, and 25504 have shown decreasing concentration trends. For example, chloroform concentrations decreased in Well 25502 from 27.6 μg/l in 2002 to 19.3 μg/l in 2004 and Well 25503 decreased from 46.5 μg/l to

30.9 µg/l. The chloroform concentration in Well 25504 is below the CSRG and DIMP is not detected. DIMP concentrations in Well 25502 decreased from 19.9 µg/l in 2002 to 9.2 µg/l in 2004 and concentrations in Well 25503 decreased from 22.2 µg/l to 16.3 µg/l. Other indicator analytes (1,2-dichloroethane, benzene, carbon tetrachloride, DBCP, DDT, dithiane, dieldrin, tetrachloroethlyene, and trichloroethylene) either show decreasing trends or were not detected. 1,2-dichloroethane and tetrachlorethylene remained above the NBCS CSRG in 2004 in Wells 25502 and 25503.

Wells 36552 and 36594 are located downgradient of the Complex (Army) Disposal Trenches and upgradient of the Bedrock Ridge System. The indicator analyte benzene was not detected in these wells. In Well 36552, carbon tetrachloride, DDT, DIMP, and PCE were not detected and chloroform concentrations decreased to below the reporting limit. Concentrations of 1,2-dichloroethane and trichloroethylene in this well decreased, but are still above the CSRGs. In Well 36594, the concentrations of indicators 1,2-dichloroethane, carbon tetrachloride, chloroform, PCE, and trichloroethylene showed decreasing trends and all except PCE were present at concentrations above CSRGs. DIMP concentrations increased slightly from 900 µg/l in 2002 to 970 µg/l in 2004.

The ongoing changes in the monitoring program highlight the need to revisit and potentially revise the monitoring networks through revisions to the 1999 LTMP during the next FYR period.

6.4.1.3 Confined Flow System

CFS monitoring is required by the On-Post ROD to identify vertical or lateral migration of contaminants to or within the CFS in the Basin A, Basin F, and South Plants areas.

Water level and water quality monitoring results were evaluated for the CFS wells. In addition to review of chemical data, this evaluation included comparisons of CFS water level data with UFS water level data to help address potential downward migration. The wells considered for the current FYR period were monitored in accordance with the LTMP. As shown in Table 6.4.1.2-1, there are 20 on-post wells sampled for water quality in the on-post CFS well network.

Of the 20 CFS wells, no indicator analytes were detected in 17 wells. Chloride, which is also an indicator analyte, is naturally occurring. Thus, the chloride concentrations in the CFS wells are compared to those in adjacent UFS wells and the trend in the CFS wells is evaluated. Assuming the UFS concentrations are higher than in the CFS, which is usually the case, an increasing trend might indicate downward migration. Chloride concentrations were lower than the concentrations in the UFS wells and showed stable or decreasing trends in the 17 wells. Thus, no downward migration is indicated for these 17 wells, including Wells 01067, 01102, 01109, 01300, 23187, 23193, 26147, 26150, 26152, 26153, 35063, 35068, 36113, 36114, 36159, 36171, and 36183.

In Wells 35067 and 35083 located west of Basin A, the organic indicator analytes were not detected, but chloride concentrations increased as shown in Table 6.4.1.3-1.

Chloride concentrations in UFS wells adjacent to Well 35067 are higher than in Well 35067. Thus, the increasing concentration trend in Well 35067 indicates potential downward migration. The vertical hydraulic gradient in this well is downward. The borelog for Well 35067 indicates that the bedrock above the screened interval is oxidized and moist to wet and thus, may not be an effective aquitard. The aquitard was described as potentially questionable in the RMA Well evaluation report (HLA 1994), which indicates that the well may not be confined. When the LTMP was developed, the CFS well network was scrutinized carefully to include wells where the well construction appeared to be acceptable and well documented, and an effective aquitard likely was present, but some uncertainty is inherent for both of these elements.

The chloride concentration in CFS Well 35083 is higher than in nearby UFS wells, which is anomalous since the source of higher chloride concentrations is not apparent. Similar chloride concentrations were reported for Well 35083 in 2002 and 2004 (Table 6.4.1.3-1), which suggests that the results are valid. The vertical gradient is downward and the well construction and aquitard appear adequate. Therefore, downward migration of chloride is possible, but the chloride levels in the shallower aquifer are lower. Since mobile organic contaminants that are present in the overlying UFS, are not also detected in this well, downward migration must not be significant. The CFS network, including these wells, will be evaluated further in the revised LTMP.

Well 02057 contains low concentrations (below 1 µg/l) of 1,1-dichloroethane and chlorobenzene that decreased between 2002 and 2004. The concentrations of both compounds have decreased since the well was last sampled in 1989. The other organic indicator analytes (aldrin, benzene, 4-chlorophenylmethyl sulfoxide, and trichloroethylene) were not detected. Chloride concentrations are lower than those in the overlying UFS wells and are stable. Typically, the vertical hydraulic gradient in this well is downward. The borelog indicates that the aquitard is questionable (HLA 1994) and no surface casing was installed. Thus, it is possible that 1,1-dichloroethylene and chlorobenzene were carried downward during drilling and the low-level detections are not caused by downward migration through the bedrock formation.
When Well 01102 was installed in 1992, it contained high levels of benzene (8,800 µg/l). The benzene concentrations in the overlying UFS are high (750,000 µg/l in Well 01534 in 1990). Benzene concentrations in Well 01102 have since decreased to below detectable levels in 2004. Consequently, it appears that the contamination was carried downward during drilling and vertical migration is not occurring.

Based on a review of the water quality data the following was concluded:

- No contamination was detected in any previously uncontaminated CFS wells.
- Water quality data from CFS wells in the Basin A, Basin F, and South Plants area indicate that no detectable vertical migration has occurred in most wells during the past FYR period, although water levels continue to show a potential for vertical flow from the UFS to the CFS.
- Two wells adjacent to Basin A show increasing trends in chloride concentrations, but not organic contaminants. One of these wells may actually be unconfined. The chloride levels in the second well are anomalous because they are higher than in the shallower zone. The wells will be evaluated further during the LTMP revision.
- One well contains low levels of 1,1-dichloroethylene and chlorobenzene that do not appear to be caused by vertical migration, but the well may have become contaminated during drilling. This well will also be evaluated further during the LTMP revision.

- One CFS Well in South Plants had relatively high concentrations of benzene when it was installed in 1992, but during this FYR period, in 2002 and 2004 there were no detections of benzene. This confirms that UFS contamination was carried downward when the well was installed, but has since attenuated. Thus, vertical migration of benzene is not occurring.

These results indicate that no significant contaminant migration to the CFS has occurred during the current FYR period. Contamination in two wells may be caused by an ineffective aquitard or contamination caused by drilling and are not indicative of downward migration through the Denver Formation. Increasing chloride concentrations in one well appears anomalous because a source for the chloride is not apparent. Well 23193, which could not be sampled in 2004, will be evaluated during the LTMP revision. These results suggest that no contaminant migration to the CFS has occurred during the current FYR period. The CFS monitoring network will be further evaluated as part of the revisions to the LTMP in the next FYR period.

6.4.1.4 NDMA Monitoring in the North Boundary Containment System Area

The On-Post and Off-Post RODs stipulate the completion of an assessment of the NDMA plume and preparation of a study that supports design refinement for achieving NDMA remediation goals specified for the boundary groundwater treatment systems. By mutual agreement, the NBCS was modified to treat NDMA in September 1997 as the result of the NDMA plume assessment. A monitoring program for wells north of the NBCS was developed in the HLA NDMA Evaluation Report (HLA 1996c). The primary objective of the program was to monitor the startup of the NDMA ultraviolet-oxidation system at the NBCS and to track the resulting changes in NDMA concentrations. Based on the results of this monitoring program, the 2000 5-Year Groundwater Summary Report (FWENC 2000l) recommended that part of the future NDMA monitoring program be incorporated into other existing programs i.e., NBCS conformance, off-post exceedance, and OGITS operational monitoring that currently include NDMA monitoring.

6.4.1.5 Off-Post Exceedance Monitoring

The purpose of the off-post exceedance monitoring program is to support the institutional controls component of the off-post remedy. This is accomplished by tracking and mapping off-post contaminants that exceed off-post CSRGs to prevent use of groundwater in areas where contaminant levels exceed CSRGs. Exceedance monitoring wells are sampled twice in five years. The RVO conducted exceedance monitoring in 2002 and 2004 and provided off-post exceedance maps to the SEO in support the well permit notification program (RVO 2003b, 2005). Table 6.4.1.5-1 provides a summary of the off-post wells included in the exceedance monitoring program during the past FYR period and Figure 6.4.1.5-1 depicts the exceedance monitoring network. The table identifies the following parameters:

- Monitoring well location
- Sampling start dates
- Analytes

Groundwater sampling is performed on a network of off-post RMA monitoring wells and private wells. The exceedance monitoring program includes all contaminants identified in the combined

CSRG lists for the NBCS and OGITS. It should be noted that private well monitoring, described in Section 6.4.1.6, is conducted in addition to the program discussed here. Water-quality data from monitoring wells and available private wells were used to construct the exceedance maps. In addition, the RVO used water-level tracking data to bolster the interpretation of flow direction and contaminant migration pathways in the off-post exceedance monitoring program.

The revised monitoring network was proposed to and accepted by the Regulatory Agencies in 2003. There were 59 Army wells and 12 private wells in the Off-Post exceedance network in FY02 and FY04 (Table 6.4.1.5-1). There were only a few deviations from the planned sampling during the FYR period. Well 37318 was damaged and could not be sampled in FY04. Wells 37355 and 37356 were destroyed and could not be sampled. Nearby private wells in the area were sampled if possible to substitute for the destroyed wells.

The observations made based on evaluations of the 2002 and 2004 exceedance maps (RVO 2003b, RVO 2005) and a review of data in the Rocky Mountain Arsenal Environmental Database are summarized below. The exceedance maps for 2002 and 2004 show contaminant distributions consistent with the previously mapped exceedance areas. While water-level fluctuations occurred off post during the period considered, flow direction and contaminant migration pathways were not affected. The RVO mapped exceedance areas for arsenic, carbon tetrachloride, chlordane, chloroform, chloride, DBCP, dicyclopentadiene, DIMP, dieldrin, fluoride, 1,2-dichloroethane, sulfate, and tetrachloroethylene. The exceedances map information can be summarized as follows:

- Chloroform, DIMP and tetrachloroethylene were the only organic contaminants that exceeded CSRGs downgradient of the OGITS.
- Chloroform concentrations downgradient from the NWBCS were reduced to below the CSRG during the early part of the current FYR period. The concentration of chloroform was above the CSRG upgradient of the southwestern end of the NPS.
- DIMP concentration trends varied in individual wells within its exceedance area, but the total exceedance area has decreased over the FYR period, particularly downgradient of the First Creek Pathway System, where the further downgradient portion of the DIMP exceedance area receded by about a mile in 2004. Figure 6.4.1.5-2 which shows the DIMP exceedance areas for 1999/2000, 2002 and 2004, depicts the significant decrease in the size of the DIMP plume between 1999 and 2004.
- Dieldrin concentrations decreased in some areas, while increased concentrations were observed in wells north of the NBCS. A narrow dieldrin exceedance area extends from near the east end of the NBCS to the NPS on the 2002 and the 2004 exceedance maps.
- Dicyclopentadiene exceedances were reported for two wells in 2002 and 2004 (Well 37065 and Well 37083). These wells are located upgradient of First Creek.
- There have been no significant changes in carbon tetrachloride concentrations, which exceeded the PQL in only two monitoring wells in both 2002 and 2004.
- In 2002 arsenic concentrations exceeded the CSRG in 10 wells but only in 4 wells in 2004. The additional exceedances in 2002 likely were false positive detections caused by an unreliable method (Method 6019) which was changed (to Method 7062) in 2003.

- Chloroform, DBCP, and NDMA concentrations in all wells evaluated in this review decreased during the current FYR period.
- No definite trends were observed for chloride and sulfate during the current FYR period.
- The fluoride exceedance areas showed little change during the current FYR period.

The contaminant trends downgradient of the NPS during the FYR period were as follows:

- The concentration of chloroform in Well 37013 was above the CSRG of 6 μg/l in FY00, FY01, and FY02 but decreased to below the CSRG in FY03 and FY04.
- The DBCP concentration in well 37013 was above the CSRG in FY02, but decreased to below the CSRG in FY04.
- The concentration of tetrachloroethylene in well 37013 was above the CSRG in FY00 and FY02, but below in FY01, FY03, and FY04.
- The concentration of arsenic in Well 37008 was just above the CSRG of 2.35 μg/l in FY04.
- Arsenic was reported above the CSRG in wells 37009 and 37013 in FY02, but likely were false positives as both wells were below the CSRG in 2004.

Downgradient of the First Creek Pathway extraction system, significant decreases in DIMP concentrations occurred during this FYR period, including:

- Well 37343 concentration decreased from 11.3 μg/l in FY00 to below the CSRG in FY01-FY04.
- Well 37041 concentration decreased from 100 μg/l in FY00 to 15.5 μg/l in FY04.
- Private well 1185C concentration decreased from 50.7 μg/l in FY00 to below the CSRG in FY04.
- Well 37407 concentration was above the CSRG during FY00 and FY04, but below the CSRG during FY01 through FY03.
- Well 37084 concentration decreased from 270 μg/l in FY00 to 14.2 μg/l in FY04.
- Well 37110 concentration decreased from 25 μg/l in FY00 to 8.01 μg/l in 2004
- Well 37396 concentration has decreased from 200 μg/l in 1994 to below the CSRG in FY00, FY03 and FY04.

Due to the changes in the exceedance monitoring program and reductions in contaminant plumes during the past FYR period, the network should be reviewed and revised as part of the LTMP revision during the next FYR period.

6.4.1.6 Private Well Network Monitoring #96

The Private Well Network program is administered by TCHD via a Memorandum of Agreement with the Army (PMRMA 1997a). Under this program, TCHD samples private wells and surface water sources in the off-post study area. Each year, sample locations are selected based on the criteria listed in the LTMP. The objectives of this sampling effort are to:

- Provide data to assist in refining the CSRG exceedance area

- Sample new wells installed in the off-post area as required by the Off-Post ROD
- Sample existing wells in response to citizens requests
- Sample CFS wells that may act as conduits for contaminants to migrate from the shallower UFS to the CFS.

In addition, TCHD samples surface water discharges from gravel operations into the South Platte River which analyzed only for DIMP, and maintains a database with demographic information regarding private wells in the CSRG exceedance area.

Annually TCHD prepares and provides a candidate sampling list for RVO, EPA, and CDPHE review. After receiving and incorporating comments, the candidate sampling list is finalized. Sampling of approximately 50 wells takes place each summer. Private Well samples are taken with the permission of the well owner. TCHD samples the wells on the candidate sampling list and the private wells recommended for sampling in the past FYR unless:

- The well has been taken out of service because of connection being established to a public water supply, or because of development in the area where the well is located.
- TCHD is unable to make contact with the well owner to obtain permission to sample.
- The property owner denies access.

As new demographic information and the water-quality data become available in the area of interest, it is entered into TCHD and RVO Environmental Databases. Approximately 250 wells and surface water sources have been collected under this program since the past FYR. The results of the program are provided annually by TCHD to the RVO, EPA, and CDPHE.

In conclusion, the Private Well Network program is functioning as intended and is meeting the objectives outlined above.

6.4.1.7 Perchlorate Monitoring

The RVO sampled twelve wells for perchlorate in response to a request from EPA in 2003. During the initial sampling round, perchlorate was detected in only 1 of the 12 wells sampled, Well 36594, at a concentration of 14.07 µg/l. This concentration was within the EPA Guidelines for perchlorate, which gives a range from 4 to 18 µg/l (EPA 1999). Well 36594 was re-sampled in 2004, and the perchlorate concentration was less than the MRL of 3 µg/l. Based on these results, the EPA, CDPHE, and TCHD agreed that no additional monitoring for perchlorate was necessary (PMRMA 2004d). Updated EPA guidance based upon equivalent exposure assumptions, gives a revised limit of 24.5 µg/l (EPA 2006). As such, the above conclusion remains valid.

6.4.1.8 Hazardous Waste Landfill Operational Groundwater Monitoring

During the multi-year operational period for the HWL, groundwater monitoring wells were sampled in accordance with the Operational Groundwater Monitoring Plan (FWENC 2001i and 2003h). Monitoring results were documented in annual groundwater monitoring reports which were submitted to the USEPA and CDPHE during this FYR period (FWENC 2002j, FWENC 2003i, FWENC 2004, TTFWI 2005b, TTECI 2006k). Results indicated no negative impacts to groundwater from ongoing waste placement activities in the HWL. groundwater monitoring will continue through the closure period which began in September 2006.

6.4.1.9 Enhanced Hazardous Waste Landfill Pre-Operational Groundwater Monitoring

During the multi-year preoperational period for the ELF, groundwater monitoring wells were sampled in accordance with the Preoperational Groundwater Monitoring Plan for the Enhanced Hazardous Waste Landfill (FWENC 2001j). Monitoring results were documented in annual groundwater monitoring reports which were submitted to USEPA and CDPHE during this FYR period (TTFW 2005b, TTECI 2006k). The results from this monitoring establish a baseline for future groundwater monitoring during the operational phase of the ELF. Groundwater monitoring will continue through the operational period which began in April 2006.

6.4.2 Surface Water

Surface water monitoring data collected between October 1, 1999 and September 30, 2004 from two gaging stations and one water-quality sampling site were evaluated for this report. Water quality data from the following gaging stations were evaluated: First Creek above 96th Avenue at RMA (Station SW24002), and First Creek at Highway 2, near RMA (Station SW37001). Surface water quality data from the First Creek at the North RMA Boundary sampling site (Sampling Site SW24004) were also evaluated. Sampling Site SW24004 is an on-post surface water sampling location specified in the ROD, while Stations SW24002 and SW37001 are off-post surface water gaging stations specified in the ROD. Water quality results from additional water quality sites in the Surface Water Sampling and Analysis Plan are described in a previous report (USGS 2005b). Water quality samples were scheduled to be collected annually and after storm events at Stations SW24002 and SW37001, and annually at Sampling Site SW24004, contingent upon surface water being available to sample at the time that sampling was scheduled or possible, as stated in the RS/S (HLA 1996a). If surface water samples could not be collected, the sample was omitted for that sampling event. For example, during 2002, a severe drought occurred and there were very few days with flow in First Creek. Additionally, Station SW37001 sometimes is impacted by backwater from the O'Brian Canal, which is not representative of the water quality in First Creek at this location. During backwater conditions, samples could not be collected.

At each gaging station or sampling site, depending on flow conditions, the exact sampling location can change by a few hundred ft. in order to optimize the straightness of the reach, the uniformness of the flow, and the uniformity and stability of the channel bottom. These steps help ensure that the constituents are well mixed along the cross section. Hydraulic conditions, water depth, and other flow characteristics are all taken into consideration when selecting the exact transect. The objective of each sampling is to safely collect samples representative of the flow conditions at the time of sampling. The USGS collects all of the surface water samples at the RMA and maintains station description folders for each site designating where the samples are to be collected.

Streamflow data were collected according to methods described in the USGS National Field Manual for the Collection of Surface Water Samples (USGS 1998). Section 1.2.1 of the USGS National Field Manual describes the selection of sampling sites in the following manner:

"Field personnel must select the point(s) or transect(s) at which samples will be collected. In most bodies of flowing or still water, a single sample site or point is not adequate to describe the sampling area's physical properties and the distribution and abundance of chemical constituents or biological communities. Location, distribution, and number of surface-water sampling sites can affect the quality of resulting data."

6.4.2.1 Analysis of Surface Water Quality Data

Surface water samples were analyzed for a suite of targeted constituents identified as COCs for surface water in the Off-post Operational Unit Endangerment Assessment/Feasibility Study (HLA 1992). The target constituents for the surface water monitoring stations included in this assessment included DIMP, chlordane, 2,2-Bis (p-chlorophenyl)-1,1-dichloroethene, 2,2-bis (p-chlorophenyl)-1,1,1-trichloroethane, tetrachloroethylene, 1,2-dichloroethane, dieldrin, dicyclopentadiene, arsenic, chloride, fluoride and sulfate.

For the target suite of organic constituents, a limited number of detections greater than the surface water standards established by the Colorado Basic Standards and Methodologies for Surface Water (CBSMSW) were found at the gaging stations and sampling location included in this assessment. A summary of surface water detections for surface water monitoring locations on First Creek near the north boundary of RMA for this FYR period is included in Table 6.4.2.1-1.

Between October 1, 1999 and September 30, 2004, two samples were collected at Station SW37001 with concentrations of DIMP above the CBSMSW. There were no other detections above CBSMSW of any of the target suite of organic constituents at any of the three surface water monitoring stations included in the Off-Post ROD for the purpose of providing water quality information. For the target suite of inorganic constituents, there were two detections of chloride and four detections of sulfate above CBSMSW at Station SW37001 and one sulfate detection above CBSMSW at Station SW24002.

Annual and storm water quality samples are collected at Station SW24002. The water quality monitoring results indicate that surface water in First Creek above 96th Avenue (Station SW24002) met CBSMSWs throughout the FYR period, with the exception of one sample with a detection of 260,000 μg/l of sulfate on March 27, 2000, which was slightly above the CBSMSW of 250,000 μg/l. The daily mean discharge at Station SW24002 on March 27, 2000 was 0.32 cubic ft. per second. The only constituent to exceed CSRGs at Station SW24002 was arsenic. Three samples collected during the FYR period exceeded the CSRG goal for arsenic of 2.35 μg/l: 3.67 μg/l on August 18, 2000; 2.39 μg/l on April 18, 2001; and 4.56 μg/l on July 25, 2004. The daily mean discharge was estimated as 0.12 cubic ft. per second on August 18, 2000. The daily mean discharge was 0.47 cubic ft. per second on April 18, 2001, and 16 cubic ft. per second on July 25, 2004. An unusually strong series of monsoon storms moved through the area between July 23-July 25, 2004. The daily mean discharge on the two days preceding the July 25, 2004 sampling event were 13 cubic ft. per second on July 23 and 42 cubic ft. per second on July 24.

Samples were collected annually during the FYR period except 2002. In FY2002 the only flow that occurred at this gaging station was during 12 days in March 2002. Because of the extremely limited flow in FY2002, only one storm water quality sample was collected that water year and no annual sample was collected. During the FYR period, all other annual and storm water quality samples were collected except for one storm sample in the 2001 water year.

All of the target analytes were analyzed in each of the 8 samples collected during the FYR period except DIMP. DIMP was deleted from the sampling plan for Station SW24002 after June 2001 in accordance with the revised analyte list provided in the Surface Water Sampling and Analysis Plan (FWENC 2001k).

Annual water quality samples are also collected at Station SW24004. The surface water quality monitoring results indicate that surface water in First Creek at Sampling Site SW24004 met CBSMSWs throughout the reporting period. The only constituent detected above its CSRG at Sampling Site SW24004 was arsenic, which was detected at a concentration of 4.34 µg/l on July 25, 2004. SW24004 is a water quality monitoring station only; streamflow is not gauged at this site. Surface water leaving RMA as measured at gauging station SW24004 met applicable water-quality standards for all of the target constituents. No flow was available for sampling during the 2002 water year at the First Creek at the North RMA Boundary gauging station. During the FYR period, all of the other scheduled annual samples were collected. DIMP was deleted from sampling plan for Sampling Site SW24004 after June 2001 in accordance with the revised analyte list provided in the sampling plan (FWENC 2001k).

Surface water samples collected at Station SW37001 occasionally contained detectable concentrations of some target organic constituents (i.e., DIMP, dicyclopentadiene and PPDDE) as well as elevated concentrations of arsenic, chloride, fluoride, and sulfate. In a few cases the concentrations of DIMP, chloride, and sulfate exceeded the applicable CBSMSWs for each of these constituents. Dicyclopentadiene concentrations were consistently below the CSRG of 46 µg/l. DIMP was detected in 4 of the 7 samples collected at SW37001 during the sampling period and at concentrations greater than the CBSMSW CSRG of 8 µg/l on March 23, 2000 (11.6 µg/l) and May 4, 2001 (49 µg/l). The daily mean discharge at Station SW37001 on March 23, 2000 was 0.33 cubic ft. per second. The daily mean discharge at Station SW37001 on May 4, 2001 was 0.15 cubic ft. per second. While the concentration of DIMP varied considerably, it appears there was a trend of gradually decreasing DIMP concentrations over time (the data was insufficient to verify this apparent trend via a rigorous statistical trend analysis). This apparent downward trend in DIMP concentration was consistent with the gradual decrease in DIMP concentrations over time in groundwater in the area. While arsenic was detected at concentrations below the CBSMSW of 50 µg/l in all 7 samples collected during the FYR period, the CSRG for arsenic of 2.35 µg/l was exceeded in 3 of the 7 samples (4.9 µg/l on May 31, 2001; 2.76 µg/l on July 26, 2004; and 3.23 µg/l on July 29, 2004). The daily mean discharge was 0.94 cubic ft. per second on May 31, 2001, and 3.4 cubic ft. per second on July 29, 2004. The daily mean discharge on July 26, 2004 was estimated at 7.0 cubic ft. per second. Chloride was detected at concentrations exceeding the CBSMSW/CSRG of 250,000 µg/l in 2 of the 7 samples collected during the FYR period (300,000 µg/l on March 23, 2000 and 440,000 µg/l on May 4, 2001, with corresponding mean daily discharges as previously noted). Sulfate was detected at concentrations greater than the CBSMSW of 250,000 µg/l in 4 of the 7 samples collected during the FYR period at Station SW37001 (490,000 µg/l on March 23; 2000; 660,000 µg/l on May 4, 2001; 280,000 µg/l on May 31, 2001; and 313,000 µg/l on April 28, 2003). The sulfate concentrations detected on March 23, 2000 and May 4, 2001 also exceeded the CSRG. The daily mean discharge for the April 28, 2003 sampling event was estimated at 1.5 cubic ft. per second. The daily mean discharges for the remaining sampling events with sulfate concentrations exceeding the CBSMSW were as previously noted.

Surface water flow was not available in sufficient quantity for sampling in the 2002 water year at Station SW37001. All other scheduled samples during the FYR period were collected with the exception of one storm sample in water year 2000.

6.4.2.2 Off-Post Areas Potentially Affected by DIMP

There is a small off-post area located near First Creek between the north boundary of RMA and Highway 2 where elevated DIMP concentrations in surface water are possible. Surface water in this off-post area could be affected by DIMP contained in shallow alluvial groundwater that at times contributes flow into First Creek. Streams that receive groundwater discharge are gaining streams. First Creek is a gaining stream during portions of the year, and during those times DIMP and other contaminants may be detected. Downstream of gaging station SW37001, First Creek flows into the O'Brian Canal. While DIMP has been detected in First Creek upstream of its confluence with the O'Brian Canal at concentrations exceeding the CSRG/CBSMSW, the O'Brian Canal (when it is flowing) contains a much greater volume of water than First Creek. Although no new DIMP data has been collected for the O'Brian Canal since 1990, the 10 water quality samples analyzed for DIMP between 1985 and 1990 support DIMP concentrations from First Creek being significantly diluted by the flow in O'Brian Canal, and it is unlikely that DIMP would be detected above the CSRG or CBSMSW downstream of First Creek. The highest concentration of DIMP measured in the O'Brian Canal between 1985 and 1990 was only 0.532 µg/1 on October 12, 1987.

6.4.2.3 Summary of Surface Water Results

For most constituents, concentration and discharge often tend to have an inverse relationship, with higher concentrations observed with lower flow rates. There are many exceptions to this pattern, and concentrations during any given sampling event depend heavily on the streamflow conditions at the time of sampling, streamflow conditions preceding the time of sampling, and the groundwater elevations in the vicinity of the gaging station or sampling site, which help control groundwater/surface water interactions.

During this FYR the detection frequency for target analytes above CBSMSWs decreased compared to the past FYR period. With the ongoing removal of organic contaminants from the groundwater in the area, concentrations of the target suite of organic constituents in surface water are expected to continue to decrease. Natural attenuation of inorganic contaminants and treatment of organic groundwater contaminants at the NBCS and the OGITS appear to be having a positive effect on First Creek water quality. The remedy is performing in accordance with the Off-Post ROD. The surface water monitoring will be reviewed and included in the revised LTMP.

6.4.3 Biota Monitoring

Biota monitoring results are detailed annually in the RMA National Wildlife Refuge Annual Progress Reports (USFWS 2000, 1999b, 1998, 1997, 1996b) and RMA National Wildlife Refuge Annual Narrative Reports (USFWS 2006b, 2006c, 2006d, 2002b). Early biomonitoring consisted mostly of wildlife land use surveys, location of wildlife, population of wildlife at those locations, and what habitat they were using. In 1991, the first contaminant-related biomonitoring started with a deer herd health study, initiation of the American kestrel nest box monitoring, and archiving and recording fortuitously collected animals. The following year, water quality was added and the need for an integrated biomonitoring plan was identified. In 1993, surface water quality monitoring continued, as did the fortuitous collections. A specific study was conducted concerning bird use and mortality around Building 111. Three research projects also began, involving European starlings, American badgers, and deer mice. In 1994, biomonitoring studies were initiated to determine contaminant levels in tissues of Mourning doves, deer mice, Plains pocket gopher, European starlings, American kestrel, great horned owls, and the American badger. The following year, black-billed magpies and aquatic monitoring were included. Subsequent years were spent refining the biomonitoring program and comparing current results with previous years' results. Since 2000, the biomonitoring plan has focused on a rotation of sentinel species including European starlings, American kestrels, American tree swallows, raptors and the black-billed magpie. Additionally, aquatic species have been sampled and efforts are underway by the USFWS to incorporate aquatic sampling into a Refuge fishery management plan. The USFWS continues to assess any diseased or dead wildlife on-site through their fortuitous sample program.

In all cases, studies determined and continue to support the fact that wildlife at the RMA is exposed to contaminants in the soil in some areas of the site. Furthermore, as cleanup has progressed since 2000, a downward trend has been noted in the number of animals affected and contaminant tissue load in animals tested. Fortuitous collections over the FYR period have indicated lower mortality numbers from those previous to 2000. The biota COCs include the OCPs, arsenic and mercury. Avian species tend to be the most sensitive to the OCPs. The bird studies suggest that dieldrin contributes to local population declines primarily through adult mortality and the reproductive processes are not markedly sensitive to dieldrin. Mammals, although exposed to the contaminants, are not as sensitive to the chemicals as are birds. IRAs and cleanup projects completed since 2000 appear to have broken major exposure pathways to wildlife. Historically, thousands of waterfowl died in the Basins. Draining the Basins and consolidating the sludges has stopped waterfowl mortalities.

Long-term biomonitoring will continue to be conducted at RMA. Long-term biomonitoring is anticipated to be conducted in accordance with the *Long-Term Contaminant Biomonitoring Program for Terrestrial Ecological Receptors at Rocky Mountain Arsenal, Revision 0* (BAS 2006b). The long-term biomonitoring program was approved by Committee on January 11, 2007. The purpose of the long-term biomonitoring program is to help evaluate the efficacy of the remedy in accordance with the requirements of Section 9.7 of the ROD, i.e., that "monitoring activities for biota will continue by USFWS in support of evaluating the effectiveness of the selected remedy." Elements of the long-term biomonitoring program are anticipated to be implemented during the next FYR and the results from this program will be discussed in the next FYRR.

6.4.3.1 Aquatic Ecosystem Monitoring

The selected remedy in the ROD states that water levels in Lake Ladora, Lake Mary, and Lower Derby Lake will be maintained to support aquatic ecosystems and that the biological health of the ecosystems will continue to be monitored.

The "Management Plan for Protection and Monitoring of Lake Ladora, Lake Mary and Lower Derby Lake during RMA Remediation" (PMRMA 2006b) documents that this requirement will continue to be fulfilled through the completion of the remedy. The plan outlines requirements for maintenance of lake levels (water quantity), surface water quality and ecological monitoring that are applicable through the completion of the remedy. Implementation of this plan will ensure that water levels will be maintained to support the desired aquatic ecosystems. Lake Ladora will be managed to support warm water recreational fisheries that support sustained populations of native and desirable naturalized game and forage fish species. The aquatic ecosystem of Lower Derby Lake will be managed to provide suitable habitat for water birds and shorebirds and to promote growth of aquatic and wetland vegetation through seasonal drawdowns in the spring and summer. This management will support accomplishment of the purposes, goals and objectives of the Refuge through the completion of the remedy.

The USFWS will monitor water quality for all lakes, fish population for Lake Ladora and Lake Mary, waterfowl use-days for Lower Derby Lake, and lake levels for all lakes, and will report results to the Army, EPA, and CDPHE annually.

6.4.4 Air Monitoring

Air monitoring results from the SWAQMP for the years 2000 through 2003 are detailed in annual air summary reports. The development of the annual summary report for the year 2004 is in progress. Data from those years and all previous years are maintained in the RMA Environmental Database. Based on the results of the monitoring program that has been conducted during RMA remediation activities since the past FYR, ambient air quality impacts from the implementation of the On-Post ROD have been minimal, with chronic and acute health risks managed well within acceptable ranges.

Ambient air, dust, and odor sampling and monitoring activities were implemented and conducted in accordance with the SWAQMP (TTECI 2006c) and Site-Wide Odor Monitoring Program Plan (FWENC 1999d). These activities included time-integrated ambient air sampling for RMA-designated COCs, dust and odor monitoring, and real-time monitoring of selected parameters. Additional air monitoring activities were conducted specifically to support individual remediation projects such as South Plants, M1 Pits, Hex Pit, Section 36 Balance of Areas, Section 30 ESL Projects, as well as the USFWS Weekend Visitor Access Program.

The established criteria included fenceline acute and chronic health criteria that are designed to ensure that the community is not adversely affected by chemical exposures during remediation. The acute criteria are also applied at specific on-site locations to be protective of visitors to RMA. An Air Pathway Analysis model is used to predict impacts from each remediation project. Results of the Air Pathway Analysis are used to prescribe the level of air and odor monitoring conducted at any time. The monitoring program is then implemented in accordance with this plan.

Data evaluation protocols for assessing RMA impacts were established for the program through extensive interaction with the Regulatory Agencies. All ARARs established in the On-Post ROD relative to air and odor quality were met, and no federal or state ambient air quality standard was exceeded because of RMA activity.

Regarding COCs, one detection of mercury was observed at the fenceline in 2000 at a level above the established acute reference concentration, but this result was believed to have been due to sample-media contamination and not to RMA remediation or construction activities. No other exceedance of fenceline health-based acute RMA risk criteria was recorded (FWENC 2001l).

There were two instances in 2002 in which chronic health risk annual action levels were exceeded at a fenceline monitoring station due to chloroform impacts believed to be associated with the South Plants Remediation. Cumulative program risks did not exceed program goals and remain well below regulatory guidelines. In each case, proper response actions and notifications were conducted accordingly, as prescribed in the SWAQMP Plan.

In 2003, an anomalous detection of DBCP at a fenceline monitoring site occurred that could not be associated directly with RMA remediation activity. In addition, a collocated EPA air sample showed no detection. The DBCP detection did not exceed any acute or chronic levels for that site. However, the single detection was included in the health risk calculations and was responsible for consuming 66 percent of the annual noncarcinogenic criteria for that chemical, which, in turn, resulted in pushing the annual hazard index (summed for all COCs) over 1.0 at that site for 2003.

Based on review and assessment of the data, no chemical concentrations exceeded fenceline or on-site health-based acute or chronic risk action levels developed for RMA.

Several short-term Particulate Matter less than 10 Micrometers in Diameter (PM-10) levels at RMA visitor locations approached internal action levels during periods of excessive high winds and dry soil conditions when regional dust was present, but no PM-10 ambient air quality standard was exceeded. As such there was no impact to public health. The former National Ambient Air Quality Standard 24-hour Total Suspended Particulate standard was exceeded on one occasion in January of 2003 at the northwest RMA fenceline. The exceedance was determined to not be a result of RMA activity. During the preparation of the FYRR use of TSP monitoring as a surrogate to confirm acceptable PM-10 levels was agreed upon.

Visible fugitive dust was typically observed at low to moderate levels in the near vicinity of project activities. Response actions in accordance with SWAQMP Plan protocols limited impacts to localized areas around remedy project sites. Consequently, there was only one documented instance where fugitive dust from on-site sources was observed crossing the RMA fenceline.

On January 3, 2002, during a period of strong, gusty winds, dust was observed crossing the RMA fence line along the eastern perimeter fence line near 7th Avenue. Airborne dust was a Denver area issue on that day, and dust was observed blowing onto, as well as away from RMA. Activities taking place at South Plants at the time included excavation, transport and placement of clean soil for cover sub-grade construction. Specific dust control activities occurring at South Plants to mitigate dust during this high wind event included the use of water during excavation, loading and placement of sub-grade. Due to the dust mitigation measures employed by the project team at the active work site, the dust sources appeared to be primarily from the inactive cover placement and re-vegetation areas of the eastern portion of South Plants and Borrow Areas 11. Both of these are also uncontaminated sources. Visible dust ceased late that afternoon.

Odor was frequently detected at and near project work boundaries during remediation in the South Plants and Section 36 areas, and on one occasion at the North Plants Remediation Project. Generally, when odors at these internal monitoring locations exceeded management action levels, the odor was controlled on-site. When occasional odors were detected at the fenceline, with one exception, they were brief in duration and below action levels, resulting in no public complaints. There was one occasion in September 2001 when odors were detected at the fenceline in conjunction with a thin bluish haze that likely emanated from the M-1 Pits Project. The odor monitoring results indicated that the state nuisance odor standard was not exceeded, although nuisance effects from the incident were reported from one off-post entity and one citizen. Odor response protocols were followed during these events as a result of the detected odors. The odor response and control protocols established to mitigate potential problems were consistently followed and effectively continued to promote compliance with the ARARs.

From program implementation through review of the data, the objectives of the SWAQMP and Site-Wide Odor Monitoring Program have been met during the second FYR period. Monitoring data quality has been acceptable and useable for meeting project objectives. The Air Pathway Analysis and monitoring programs are functioning as designed and are meeting the objectives and requirements of the On-Post ROD. The SWAQMP and Site-Wide Odor Monitoring Program collectively have demonstrated that they are effective in supporting remediation at RMA while supporting requirements and objectives designed to ensure the protection of public health and the minimization of nuisance odors. To date, they have also been successful in characterizing impacts of remediation so as to be protective of public health and to minimize nuisance odors.

Additional discussion related to site-wide air monitoring, air ARARs and ROD compliance is included in Section 7.4.4.

7.0 ASSESSMENT

The purpose of the FYR is to conduct a protectiveness level review to determine if the remedies for RMA defined in the RODs, remain protective of human health and the environment, are functioning as designed, and if necessary O&M is being performed, considering the changes in ARARs and TBCs that occurred in the FYR period.

It should be noted that projects that have been administratively transferred from IRA status to a ROD-defined project are reviewed concurrently with the ROD project to which they have been transferred.

7.1 Question A: Is the remedy under construction functioning as intended by the decision documents?

Consistent with the EPA FYR Guidance (EPA 2001a) the following topics should be evaluated for projects under construction:

> Is the remedy being constructed in accordance with the decision documents and design specifications?

Is the remedy expected to be protective when complete and will performance standards likely be met?

Are access controls and institutional controls in place to prevent exposure during construction?

7.1.1 Construct the Enhanced Hazardous Waste Landfill #11

The construction of the ELF is being conducted in accordance with the decision documents and design specifications discussed in Section 4.3.1.1. The ELF is expected to be protective when complete and performance standards will likely be met. As a clean construction project prevention of exposure to COCs has not been a concern. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements.

While preparing this FYRR, a ROD Amendment (TTECI 2005a) providing for removal of Basin F principal threat soil and insitu management of Lime Basins wastes was prepared and approved as described in Section 6.3.11. In preparing the ROD Amendment, adequacy of remaining landfill capacity was a factor considered. As a result, sufficient ELF capacity remains available and remaining capacity is carefully monitored.

7.1.2 Existing (Sanitary) Landfills Remediation Section 30 #22

The construction of the ESL Section 30 project is being conducted in accordance with the decision documents and design specifications discussed in Section 4.3.1.2. The ESL Section 30 project is expected to be protective when complete and performance standards will be likely met. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. As an excavation project, long-term O&M is not relevant to this site. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements.

As noted in Section 4.3.1.2, the ROD did not anticipate MEC at this project. Regardless, because the design evaluation indicated the possibility for MEC, UXO spotters were present during excavation activities. Correctly anticipating the MEC suggests that the remedy, as implemented through the RI/FS, the ROD, the design evaluation, the design specifications, site procedures and other change documentation is functioning as intended.

7.1.3 Munitions (Testing) Soil Remediation Part II #25

The Munitions Testing Part II project is being conducted in accordance with the decision documents and design specifications discussed in Section 4.3.1.3. The Munitions Testing Part II project is expected to be protective when complete and performance standards will likely be met. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. As an excavation/removal project, long-term O&M is not relevant to this project. Implementation of the recently revised RMA institutional controls (PMRMA 2006x) continues to satisfy the Refuge Act and ROD requirements.

As noted in Section 4.3.1.3, the ESA-4a boundaries were modified several times during project implementation. Clearly, the ROD anticipated possible UXO in a number of medium groups and subgroups at RMA, and contemplated use of geophysical methods to locate and recover these items. The boundary changes at ESA-4a evidence a functioning, iterative remedy process.

The CERCLA process recognizes the ROD as one step in a long sequence of remedy activities. The remedy process did not blindly proceed with imperfect ROD boundaries. Instead, as new data became available, the prior ROD conclusions were challenged and, where appropriate, the ROD conclusions were modified. Because lessons learned are being embraced at all points in the remedy process, it is likely the performance standards for this project will be met. For that reason the remedy, as implemented through the RI/FS, the ROD, the design evaluation, the design specifications, the site procedures and other change documentation, is functioning as intended. For additional background also see Sections 4.5.1.3, 6.3.4 and 7.2.3.9.

7.1.4 Section 36 Bedrock Ridge Groundwater Barrier Plume Extraction System #28

The installation of the additional Section 36 Bedrock Ridge Groundwater Plume Extraction well is being conducted in accordance with the decision documents and design specifications discussed in Section 4.1.1.1. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements.

The continuous evaluation of the Bedrock Ridge extraction system during the FYR period led to the decision to modify the system to improve plume capture. The data that formed the basis for this conclusion were presented to the Regulatory Agencies during Water Team meetings throughout 2003 and discussed in the 2003 and 2004 OARs (PMRMA 2005b, 2005c). The decisions to perform pumping tests and to add a well were made in agreement with representatives from the Regulatory Agencies in a meeting on June 11, 2003. The extraction system will be modified during the next FYR period. Since this is an internal system and any water not being captured by it would migrate toward the NBCS, the existing by-pass of the system does not have any adverse effects on the overall protectiveness of the remedy.

As noted in Section 4.1.1.1, the system was unable to achieve capture between the two westernmost extraction wells. Improvements to the system, which involved adding an extraction well were completed in July 2005. Although the well installation should achieve capture, additional evaluation will be required. Initial long-term pumping tests indicated that the performance standards would be met with the addition of a new extraction well. It is premature to assess whether the Section 36 Bedrock Plume Capture System is functioning as intended. Initial long-term pumping test results indicted that the performance requirements would be met with the addition of the new extraction well. For that reason this project is an issue addressed in Section 8.0.

7.1.5 Miscellaneous RMA Structures Demolition and Removal Phase II #30

The construction of the Miscellaneous RMA Structures Demolition and Removal Phase 2 project is being conducted in accordance with the decision documents and design specifications discussed in Section 4.4.1.1. While preparing this FYRR, a DCN was prepared and approved by Regulatory Agencies that reclassified a number of structures for "future use" that the ROD had identified for "no future use" (TTECI 2006f). The Miscellaneous Structures Phase 2 project is expected to be protective when complete and performance standards will likely be met. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. As a demolition project, long-term O&M is not relevant. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements.

7.1.6 South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2 Part 1 and 2 #34

The construction of the South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2 Part 1 and 2 is being conducted in accordance with the decision documents and design specifications discussed in Section 4.3.1.4. The South Plants Balance of Areas and Central Processing Areas Phase 2 project is expected to be protective when complete and performance standards will likely be met. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. The general RMA, Central Remediation Area, and project-specific exclusion boundary access controls as well as signage and activities controls, such as SafeRAC, protect the public from accessing this project where waste is left in place. In addition, institutional controls exist to prevent exposure to the waste, such as prohibitions on excavation, drilling, tilling, grading, or construction of any sort other than actions taken as part of the remedy (PMRMA 2006a). As an excavation and subgrade construction project, long-term O&M is not relevant. Long-term O&M will be relevant to future cover construction planned at this location in a later phase of this project. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements.

As noted in Section 4.3.1.4, elevated chloroform emissions were identified during Part 1 of this project. The project was immediately suspended and the suspected chloroform source was covered with soil. Corrective actions were developed in coordination with the Regulatory Agencies and included additional excavation controls, and real time monitoring. The chloroform emissions for the balance of the project were minimal. Lessons learned were documented and future RMA projects began accounting for emissions from historical spill areas. This early indicator of potential remedy failure was promptly addressed and the remedy is now functioning as intended.

7.1.7 Section 36 Balance of Areas Soil Remediation #36

The construction of the Section 36 Balance of Areas Soil Remediation project is being conducted in accordance with the decision documents and design specifications discussed in Section 4.3.1.5. The Section 36 Balance of Areas project is expected to be protective when complete and performance standards will likely be met. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. Long-term O&M is required for that part of the project within the Army-maintained area. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements.

During project implementation, evaluation of soil data located at greater depths was performed. This effort identified soils exceeding acute Site Evaluation Criteria that, in the absence of additional institutional controls, warranted remediation. This soil was excavated and disposed in the HWL and additional sampling was performed. As a result, that early indicator of potential remedy failure has been addressed.

7.1.8 Basin F Wastepile Remediation #43

The construction of the Basin F Wastepile Remediation project is being conducted in accordance with the decision documents and design specifications discussed in Section 4.3.1.6. The Basin F Wastepile project is expected to be protective when complete and performance standards will likely be met. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. The general RMA, Central Remediation Area, and project-specific exclusion boundary access controls as well as signage and activities controls, such as SafeRAC, protect the public from accessing this project. As an excavation project, long-term O&M is not relevant. Long-term O&M will be relevant to future cover construction planned at this location in a later phase of the remedy. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements.

7.1.9 Basin F and Basin F Exterior Remediation Part 1 #45

The construction of the Basin F and Basin F Exterior Remediation Project Phase 1 is being conducted in accordance with the decision documents and design specifications discussed in Section 4.3.1.7. The Basin F Exterior project is expected to be protective when complete and performance standards will likely be met. RMA site access restrictions and project-specific health and safety measures have ensured the safety workers and visitors during construction. As an excavation project, long-term O&M is not relevant. Long-term O&M will be relevant to future cover construction planned at this location in a later phase of the remedy. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirement.

During project implementation, evaluation of soil data located at greater depths was performed. This effort identified soils exceeding acute Site Evaluation Criteria that, in the absence of additional institutional controls, warranted remediation. This soil was excavated and disposed in the HWL and additional sampling was performed. As a result, that early indicator of potential remedy failure has been addressed.

7.2 Question A: Is the operating remedy functioning as intended by the decision documents?

Consistent with the EPA FYR Guidance, where relevant, the following topics are considered during the assessment:

<u>Remedial Action Performance</u>

Does the Remedial Action continue to be operating and functioning as designed?

Is the Remedial Action performing as expected and are cleanup levels being achieved?

Is containment effective?

<u>Systems Operations/O&M</u>

Will operating procedures, as implemented, maintain the effectiveness of the response actions?

Do large variances in O&M costs indicate a potential remedy problem?

Is monitoring being performed and is it adequate to determine protectiveness and effectiveness of remedy?

Implementation of Institutional Controls and Other Measures
Are access controls in place and preventing exposure (e.g., fencing and warning signs)?

Are Institutional controls in place and preventing exposure?

Are other actions (removals) to address immediate threats complete?

Opportunities for Optimization
Do opportunities exist to improve performance and/or costs of monitoring, sampling and treatment systems?

Early Indicators of Potential Issues
Do frequent equipment breakdowns or changes indicate a potential risk?

Could other issues or problems place protectiveness at risk?

7.2.1 Operating Groundwater Remedial Actions in the On-Post OU

The On-Post groundwater remedies are assessed against the criteria described above using the results and information presented in Section 4.1.2 and Section 6.4.1.

7.2.1.1 Shell Disposal Trenches Slurry Walls (dewatering) #17

The Shell Disposal Trenches Design Document (RVO 1997a) specified that the water levels should be lowered below the disposal trenches; however, the design document determined that the groundwater was already below the trenches, so dewatering was unnecessary.

Based upon the information provided in Section 4.1.2.1 of the FYRR the slurry wall is effectively meeting the ROD goals, including containment as defined in the ROD. The effectiveness of the slurry wall is demonstrated by a reduction in the northerly hydraulic gradients inside the slurry wall enclosure and larger head differences across the slurry wall on the north side, especially at the northeast corner where leakage of the IRA slurry wall was suspected.

Based on the limited water-level data collected during the FYR period, it appears that the groundwater elevations have remained below the bottom of the trenches except at one location. This is based on six borings where the trench bottom elevations were determined during the RI, and the groundwater elevations were lower at five of the six locations during this FYR period. The water table appears to be slightly above a trench bottom at one boring location in December 2004, and February and September 2005 and likely is related to infiltration of precipitation during the latter part of the FYR period.

The remedy appears to be functioning as intended except for the one location where water levels are above the trench bottom. However, the fact that water level measurements were not collected from the monitoring wells inside the slurry wall during three of the five years in this

FYR period makes it difficult to verify that the remedy was functioning as intended during that period. Also, Well 36534 was damaged but based on discussions in Water Team meetings it was decided that the well did not need to be replaced. In June 2005, Well 36536, located inside the slurry-wall enclosure at the southwest corner, contained sediment in the bottom of the well and the water level could not be measured. It was cleaned out in July 2005 to better evaluate the water elevation inside the slurry-wall enclosure. The water levels were measured in September 2005, after the end of the current FYR period. However, any groundwater contamination migrating out of this area does not impact protectiveness due to site-wide remedy elements, including downgradient water treatment systems and institutional controls.. These issues are identified in Section 8.0

7.2.1.2 Complex (Army) Disposal Trenches Slurry Walls (dewatering) #17

Dewatering has enhanced an inward hydraulic gradient present at the two well pairs adjacent to the Complex Trenches slurry wall. Thus, containment has been achieved at the slurry wall as required by the ROD.

The Design Document (RVO 1997a) specified that the water levels should be lowered to below the trench bottoms and established target groundwater elevations to be used to determine that the dewatering goals would be achieved. Estimates of the time required to meet the dewatering goals were also made in the Design Document and the Groundwater Extraction System Operating and Functional Report (FWENC 2001a). In the design document, groundwater modeling was used to estimate that it would take five years or less to lower water levels sufficiently to meet the dewatering goals based on the initial conditions in 1996 and the specific conditions assumed in the model. The OFR provided data and assessment to indicate that as of August 2002, at a pumping rate of 3 gallons per minute, the dewatering goal of lowering the water table below the bottom of the disposal trenches could be achieved in a one and a half-year timeframe.

The Complex (Army) Disposal Trenches dewatering system had not attained the dewatering goals by the end of FYR period, as water levels had not yet been lowered below the trench bottoms at one of two compliance wells. The goal was nearly attained, however, because the water elevation in compliance well 36217 came within 0.3 feet of the target elevation. As described in Section 4.1.2.2, since the dewatering system began operation in 2001, the design flow rate was only achieved during brief periods, and could not be maintained consistently throughout the FYR period because of operational limitation at the BANCS These factors included treatment capacity limitations, recharge capacity limitations due to biofouling of the recharge trenches, and declining water levels in or near the dewatering system. The RVO alleviated the treatment and recharge capacity limitation in a timely manner, and will evaluate the declining water levels, which occurred at the end of the FYR period. This evaluation will occur during the next FYR period (i.e. in 2007), when more data can be evaluated. The RVO has attempted to meet the design flow rate of 3 gpm or maximize the rate when 3 gpm could not be achieved due to the reasons previously identified.

Although meeting the dewatering goals within a specific time period is not required, explanation of differences between the actual response in water levels due to operation of the dewatering system and the estimates in the Design Document and the Operating and Functional Report is appropriate. Regarding the modeling estimate of 5 years or less to meet the dewatering goals, the average flow rate for the first four years of operation (through 6/16/2005) was 1.4 gpm, which is 30 percent less than the flow rate in the model simulations. A lower flow rate causes the time required to reach the dewatering goals to increase compared to the model estimate. Additionally, the actual hydrologic conditions were different than those assumed in the groundwater model (i.e., the initial water levels were higher in 2001 than in 1996 when the model predictions were made, and except for 2002, recharge likely was greater than that assumed in the model. Both of these factors increase the time needed to meet the dewatering goals compared to the model estimate. The dewatering timeframe estimates and conclusions in the Operating and Functional Report only apply to the first year and a half of operation. The water-level response to pumping during that time was greatly affected by the drought in 2002 and is not representative of conditions during the subsequent years, when normal precipitation occurred. Consequently, the dewatering timeframe estimates and conclusions in the Operating and Functional Report are not valid for the entire FYR period.

RVO believes that the dewatering goals may not be achieved until the RCRA-equivalent covers are installed, which will limit the amount of infiltration from precipitation into groundwater in the area inside the slurry wall. However, achieving the dewatering goal of lowering the water levels below the trenches before the covers are constructed was not a requirement in the ROD, the Design Document, the CCR, or the Operating and Functional Report. The Complex (Army) Disposal Trenches dewatering system had not attained the dewatering goal in one of the two compliance wells by the end of FYR period. However that was not a requirement, and prior to cover construction, the dewatering system is performing as expected in the ROD and Design Document

7.2.1.3 Rail Classification Yard Treatment System and Motor Pool Area Treatment System #58

The Rail Yard and Motor Pool Systems were evaluated based on the performance data presented in the OARs (PMRMA 2005a, 2005b, 2005c, RVO 2004a, 2003a). The Motor Pool extraction system was shut off in April 1998 and shut-off monitoring was conducted through December 2003 (PMRMA 2005b). Approval of the CCR for the Motor Pool extraction system is anticipated during the next FYR period. The need for future groundwater monitoring in the Motor Pool area will be evaluated as part of the revision to the LTMP. The Rail Yard extraction and treatment system continues to operate.

The ROD established CSRGs for trichloroethylene and DBCP at the ICS. These CSRGs apply at the Rail Yard treatment system, which continues to meet the effluent requirements in compliance with the ROD. There were no exceedances of CSRGs in the effluent during the FYR period. The Rail Yard plume consists only of DBCP. Trichloroethylene was present in the Motor Pool. The CSRG list from the Rail Yard system will be reviewed during the LTMP revision.

The Rail Yard system is designed as a capture system. Capture of the DBCP plume is demonstrated with water-table contouring and plume-edge and downgradient water-quality monitoring. Monitoring downgradient of the Rail Yard recharge wells showed that recharge in this area, which causes mounding of the water-table, did not result in residual DBCP, which is believed to be present in the aquifer sediments above the water table, to migrate into the groundwater at concentrations above the CSRG.

The CCR for the Irondale shutdown was approved by EPA on May 21, 2003. Approval of the CCR for the Motor Pool extraction system is anticipated during the next FYR period.

Based on this review, it can be concluded that the Rail Yard System is operating as intended in the ROD by limiting the migration of the DBCP plume. With decreasing influent concentrations, it is anticipated the extraction from the Rail Yard plume will be discontinued during the next FYR period. Specific shut-off criteria and monitoring for this system are proposed as part of the revisions to the LTMP.

7.2.1.4 Basin A Neck Containment System #59

The performance of BANCS during the FYR period is described and evaluated in the OARs (PMRMA 2005a, 2005b, 2005c, 2004b, 2003a). All extracted groundwater was effectively treated and contaminant levels in reinjected water were below the CSRGs. Treatment of groundwater from the North of Basin F Extraction Well was discontinued in 2000 when the well was removed from service.

A significant mass of groundwater contamination migrating through the Basin A Neck area was effectively captured and treated during the FYR period. The BANCS continues to accelerate the groundwater cleanup at RMA through contaminant removal close to the source areas.

The effectiveness of treatment of these compounds is discussed above. The discussion below addresses other compounds detected at the BANCS treatment plant. The following 32 compounds were detected in the BANCS influent during the FYR period:

> 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, 1,2-dichlorobenzene, 1,4-dichlorobenzene, alpha-benzene hexachloride, alpha-chlordane, alpha-endosulfan, aldrin, benzothiazole, cis-1,2-dichloroethene, chloride, chromium, DBCP, DIMP, dimethylmethylphosphate, endrin aldehyde, endrin ketone, endosulfan sulfate, gamma-chlordane, heptachlor, heptachlor epoxide, isodrin, isophorone, methoxychlor, n-nitrosodimethylamine (NDMA), 2,2-bis-(p-chlorophenyl)-1,1-dichloroethane, 2,2-bis-(p-chlorophenyl)-1,1-dichloroethene, selenium, sulfate, supona, thallium, and trans-1,2-dichloroethene.

Only the following 11 compounds were detected in the BANCS effluent during the FYR period:

> benzothiazole, chloride, chromium, DIMP, dimethylmethylphosphate, methyl ethyl ketone, methyl-n-butyl ketone, NDMA, selenium, sulfate, and thallium.

Although CSRGs were not developed for the BANCS for these 11 compounds, it is informative to compare the concentrations detected in the BANCS effluent to the CBSGs. It should be noted that benzothiazole, dimethylmethylphosphate, methyl ethyl ketone and methyl-n-butyl ketone do not have CBSGs. Of the remaining 7 compounds detected in the effluent, CBSGs or PQLs were exceeded for chloride, DIMP (in one of 22 samples), NDMA, sulfate, and thallium. Of these compounds, only DIMP is treated by the BANCS. Methyl ethyl ketone and methyl-n-butyl ketone were not detected in the influent and are questionable detections.

The groundwater downgradient of the BANCS flows to the NWBCS. Attenuation of the contaminant concentrations occurs between the BANCS and NWBCS such that the CSRGS and/or CBSGs for the above compounds are met in the NWBCS influent and effluent.

The highest concentration of NDMA of 0.354 µg/l in the BANCS effluent occurred in April 2000 when the North of Basin F Extraction Well was still operating and the extracted water was treated at the BANCS; however, the BANCS does not have a treatment system for NDMA. The PQL for NDMA at the NBCS, NWBCS and OGITS during this FYR period was 0.033 µg/l. NDMA concentrations are higher north of Basin F than in other areas of RMA where groundwater is extracted for treatment at the BANCS. Since the North of Basin F Extraction Well was shut down, the NDMA concentrations in the BANCS effluent have decreased with concentrations of 0.042 µg/l in January 2004, 0.049 µg/l in April 2004, 0.046 µg/l in July 2004 and less than 0.021 µg/l in October 2004.

Historical groundwater monitoring and monitoring during the FYR period (in Wells 26006 and 27025) have shown that NDMA concentrations decrease to below detectable levels downgradient of the BANCS well before reaching the NWBCS. With the decreasing concentrations of NDMA in the BANCS influent and effluent due to shutdown of the North of Basin F Extraction Well, concentrations are expected to decrease to below detectable levels in the downgradient wells.

It can be concluded that the BANCS remedy is protective and that the BANCS is performing as intended in the ROD as clarified in the 2004 Memorandum for Record (RVO 2004b).

7.2.1.5 Northwest Boundary Containment System #61

The performance of this system during the FYR period is described and evaluated in the OARs (PMRMA 2005a, 2005b, 2005c, 2002c, 2001a). All groundwater intercepted and treated was reinjected with contaminant levels below CSRGs except for one exceedance of dieldrin in January of 2003. After this occurrence, the carbon changeout procedure for the treatment plant was modified to ensure that breakthrough of dieldrin would not occur and that protectiveness was maintained. No further exceedances have been identified since the new carbon changeout procedure was implemented.

In the original portion of the NWBCS, a reverse hydraulic gradient was maintained and water-table contouring and water-quality monitoring were used to confirm that the plumes were captured at the ends of the system. At the NWBCS Southwest Extension, which is a capture system design and does not require a reverse hydraulic gradient to be effective, water-table contouring and plume edge water-quality monitoring were used to demonstrate plume capture.

Water-quality monitoring in downgradient conformance wells was used to confirm effective containment of the plumes. Contaminant concentrations have been below PQLs or CSRGs in most downgradient conformance wells, except for a few isolated sampling events, which were individually evaluated. The arsenic detection in Well 37331 in 2001 was rejected by the RMA laboratory support group in March 2004 because of problems with analytical method 6010, which has not been used since 2002. This method was subject to random false-positive detections near the reporting limit due to surges in the instrument and is also subject to interferences from other compounds. The current analytical method (7062) which has a lower reporting limit (1 µg/l) is not subject to interferences and subsequent samples showed no exceedances in this well. The elevated chloroform levels in Well 37333 were suspected to have been caused by cross contamination of sampling equipment, and this problem has been corrected. The well was resampled and the exceedances were not confirmed (PMRMA 2002c).

An elevated level of dieldrin occurred in conformance Well 37332 in 2003 likely was related to the effluent exceedance in January 2003, which is described above. Well 37332 was resampled one month later and the concentration was below the PQL.

Contaminant concentrations in groundwater approaching the system are decreasing. For example, the average influent concentration in 1991 of chloroform was approximately 14 µg/l, whereas in 2004 the average had dropped to 2.6 µg/l. This trend likely results from a combination of the effects of cessation of RMA production activities in the early 1980s, implementation of IRAs in the late 1980s and early 1990s, implementation of the remedy thus far, and natural attenuation.

It can, therefore, be concluded that the NWBCS is performing as intended in the ROD and meets the protectiveness objectives for the system. Specific shut-off criteria and monitoring for this system (among others) will be evaluated as part of the revisions to the current LTMP.

7.2.1.6 North Boundary Containment System #62

The performance of the NBCS system during the FYR period is described and evaluated in the OARs (PMRMA 2005a, 2005b, 2005c, 2002c, 2001a). Groundwater extracted was effectively treated to contaminant levels below the CSRGs before reinjection, thereby meeting the effluent compliance requirements. The ultraviolet-oxidation treatment system, which was used to treat NDMA since September 1997, has been effective in achieving the established goal for NDMA except for one effluent exceedance in October 2002. The exceedance occurred on October 2, 2002 with a measured NDMA concentration of 0.056 µg/l. The NDMA concentration in a second sample collected on October 22, 2002 was below the PQL of 0.033 µg/l. NDMA concentrations in all downgradient NBCS conformance wells were below the PQL during the FYR period. One treatment plant effluent analysis for fluoride showed a concentration above the CSRG during FY01. The evaluation of this exceedance concluded that the analytical method used for fluoride is subject to interferences from other compounds and did not provide the level of accuracy necessary to establish whether the fluoride concentrations were above or below the CSRG. Previous and subsequent analyses to the reported exceedance, using a different analytical method that is fluoride-specific and not subject to interferences, were below the CSRG. Thus, it is extremely unlikely that a CSRG exceedance occurred in FY00. When the analytical method was permanently changed to a fluoride-specific method, the CSRG exceedances no longer occurred. Given that the appropriate changes were made to the analytical methodology for fluoride and that the CSRG is no longer exceeded, this issue is considered resolved.

A reverse hydraulic gradient was maintained in the alluvium throughout the FYR period. A flat to small forward gradient was present at two unconfined Denver well pairs (23540/23541 and 23542/23543) adjacent to the slurry wall. The presence of contaminants at levels above CSRGs in the downgradient well of one of these pairs raised concerns about the potential bypass of the slurry wall at this location. However, analysis of the chemical and hydrogeologic data for this area (described in Appendix C) indicate that bypass is not occurring. At Well pair 23540/23541, concentrations of most constituents (except chloride) are lower in the upgradient well than in the downgradient well. This relationship is not readily explained by bypass, which is expected to lead to lower concentrations in the downgradient wells. The hydrogeologic data in the vicinity of these wells suggests this well pair may be completed in sandstone lenses that are not continuous. Thus, the occurrence of contaminants at levels above the CSRGs in the downgradient wells are interpreted to be due to residual contamination.

Several contaminants were detected at concentrations above CSRGs in downgradient conformance wells. These contaminants include 1,2-dichloroethane, chloride, dieldrin, DIMP, fluoride and sulfate. The occurrence of these constituents at levels above CSRGs raised concerns about the effectiveness of the NBCS. However, historical data presented in Appendix C suggest that these detections are not related to system performance problems, but rather are caused by slow migration through fine-grained sediments and/or by desorption of residual contamination downgradient of the NBCS slurry wall. This interpretation is based on the following observations:

- Reverse gradients were maintained in the alluvium at the slurry wall upgradient of all of the alluvial conformance wells with CSRG exceedances. The hydraulic connection between the upgradient and downgradient areas was effectively interrupted, particularly in the alluvial system. Two downgradient conformance wells completed in the unconfined Denver Formation exceeded CSRGs, which is attributed to slow migration through fine-grained sediments, not bypass.

- The downgradient conformance wells that contain dieldrin do not contain other more mobile organic constituents (such as chloroform and carbon tetrachloride) that are present upgradient of the NBCS. This suggests that the more mobile constituents were flushed from the downgradient areas while dieldrin persists due to its stronger tendency (relative to the other compounds) to adsorb to organic matter in aquifer materials.

- Mobile constituents in most downgradient wells within a half mile of the NBCS have steadily decreased since 1992, in many cases to levels below CSRGs, suggesting that the contaminant plumes have been effectively captured by the NBCS and the more hydraulically transmissive areas downgradient of the wall are being effectively flushed by the treated recharge water.

The sulfate natural attenuation goal at the NBCS effluent was achieved within five years as discussed in the 2000 FYR, rather than the predicted 25 years as stated in the On-Post ROD. The chloride concentrations in the NBCS effluent during this FYR period increased slightly in 2002 due to start-up of the South Channel Wells, then continued the downward trend and are now approaching the CSRG. It is expected that the CSRG will be achieved much sooner than the required 30 years (2026) in the On-Post ROD. The South Channel Wells are located in a high concentration area approximately 1000 feet upgradient of the NBCS. Commencement of pumping in these wells caused the influent concentrations of chloride and other contaminants to increase in 2002. Since chloride is not treated by the NBCS, influent and effluent concentrations are similar. The chloride natural attenuation is therefore deemed to be in accordance with expectations (MKE 1996). More information regarding chloride and sulfate attenuation as it pertains to NBCS operations is provided in the FY 2004 OAR (PMRMA 2005c).

Upgradient contaminant concentrations are decreasing at the NBCS. Average influent concentrations in 1991 for DIMP were about 100 µg/l, while in 2000 they had dropped to about 50 µg/l, and in 2004 the average was about 28 µg/l. This trend is likely the result of a combination of the effects of cessation of RMA production activities in the early 1980s, implementation of IRAs and other remedy activities in the 1980s, and natural attenuation. Operational changes were implemented during this FYR period to ensure that protectiveness is maintained. The NBCS was optimized with the addition of two extraction wells south of the NBCS that will expedite the remediation of groundwater in this area and potentially reduce the time the NBCS has to operate. These wells also are intended to provide additional operational flexibility, help maintain a reverse gradient across the system, and prevent plumes located upgradient of the NBCS from migrating toward less contaminated areas that also are upgradient of the NBCS.

Further enhancements to the NBCS operation are expected to be achieved with implementation of the planned in situ biological treatment in the area of the former North of Basin F IRA system during 2005. The purpose of the NBCS Enhancement is to reduce the load of contaminants on the NBCS with upgradient in situ biological treatment. The in situ anaerobic treatment using hydrogen release compound was selected based on studies conducted by the EPA SITE program (TTEMI 2003) and details about the injection and monitoring approach are described in the design document (George Chadwick Consulting 2004).

During the FYR period, some localized changes in water levels and flow directions occurred upgradient of the NBCS, but did not negatively impact plume migration near the NBCS or containment by the NBCS. The NBCS slurry wall is keyed into bedrock highs at both ends of the system where the alluvium is unsaturated. As shown in the water table maps in the OARs (PMRMA 2005a, 2005b, 2005c, 2003b, 2002a), the groundwater flow direction in the bedrock at the ends of the system is inward toward the center of the system. This inward bedrock flow is uncontaminated. Thus, localized changes in flow directions upgradient of the NBCS cannot cause bypass around the ends of the system.

Falling water levels were part of the justification for shutting down the North of Basin F extraction well during the FYR period. However, the majority of the water level declines near the North of Basin F Well occurred prior to this FYR period, and water levels were relatively stable during the period.

In the same area as the North of Basin F Extraction Well, monitoring-well installation prior to hydrogen release compound injection indicated a change in groundwater flow direction at the North Boundary Enhancement implementation site, and resulted in changes to the hydrogen release compound barrier. The extent of a small alluvial channel in the southernmost part of Section 23, where the groundwater flow had been interpreted as easterly, was different than expected and the alluvium was unsaturated. Consequently, the flow occurs in the bedrock where the flow direction is northerly. A short distance north of this alluvial channel, the alluvial saturated thickness increases significantly, and the flow direction is northerly, so regardless of the extent of the alluvial channel and whether the alluvium is saturated or unsaturated at the North Boundary Enhancement site, the groundwater flow direction toward the NBCS has not changed.

Startup of the South Channel Wells 24355 and 24356 in Section 24 in October 2002 caused a lowering of water levels in the northern part of Sections 23 and 24. For example, water levels declined 2.1 ft. between July 2002 and July 2004 in Well 24101. One of the objectives of these wells is to prevent the Basin F plume from shifting eastward into less contaminated areas upgradient of the NBCS, as a greater proportion of flow in the extraction wells is from the east side of the system. Additional pumping from the South Channel Wells, which are located near the center of the system, would tend to cause the plumes to shift toward the center of the system. Concentration declines of carbon tetrachloride, chloride, chloroform, dieldrin, DIMP, and NDMA in extraction Well 24316 in FY 2004 (PMRMA 2005c) suggest that the South Channel Wells have stabilized or even reversed the eastward shift in the Basin F plumes. These reductions in concentrations in Well 24316 may also, in part, be related to a general decrease in contaminant concentrations upgradient of the NBCS.

Based on the evaluation presented above, the NBCS met the On-Post ROD objective of containment of the contaminant plumes migrating towards the North Boundary. Specific shut-off criteria and monitoring network revisions for this system will be evaluated as part of the revisions to the current LTMP. Concerns about the presence of elevated contaminant levels in downgradient conformance wells will be revisited when considering the performance monitoring well network in the revised LTMP.

7.2.1.7 South Lakes Plume Management #64

As noted in Section 4.1.2.9, the ROD requirement for lake level maintenance was not performed during the FYR period primarily because lake level adjustments were necessary to address water needs for remedy activities. However, an evaluation of contaminant migration was conducted and completed in accordance with the *Rocky Mountain Arsenal South Lakes Sampling and Analysis Plan for Groundwater* (USGS 2001a) during the FYR period. Groundwater monitoring results showed that the contaminants from the South Plants plume were not detected in the point of compliance (i.e. point of discharge) wells or in Lake Ladora at concentrations exceeding the CBSGs. Since a reverse hydraulic gradient was not maintained during a significant portion of the monitoring period, the results showed that contaminants did not migrate into Lake Ladora even under the most unfavorable flow conditions. These data confirm that South Plants plumes are not migrating into the lakes at concentrations exceeding CBSGs in groundwater (USGS 2004a). Based on the results of the South Lakes groundwater monitoring study, the decision was made to proceed with an ESD to remove the lake level maintenance required by the ROD for plume management which was approved by EPA on March 31, 2006 (TTECI 2006a). Based upon the discussion above, the South Lakes lake level maintenance is identified as an issue in Section 8.0.

7.2.2 Operating Groundwater Remedial Actions in the Off-Post OU

7.2.2.1 Off-Post Groundwater Intercept and Treatment System #94

In general, groundwater extracted from the First Creek Pathway and NPS extraction wells was effectively treated and reinjected with contaminant levels below the CSRGs during this FYR period. However, some treatment plant effluent analyses for arsenic and fluoride showed concentrations above the CSRGs during the FYR period. Evaluation of these reported exceedances concluded that the analytical methods used for these two analytes were not appropriate to provide the level of accuracy necessary to establish whether these compounds were above or below the CSRGs. Definitive conclusions about the effluent concentrations for these compounds could not be made for part of the FYRR period. However, exceedances of CSRGs were extremely unlikely. When the analytical methods were changed for arsenic and fluoride, there were no CSRG exceedances. Given that the appropriate changes were made to the analytical methodology for arsenic and fluoride such that more reliable methods will be used, this issue is considered resolved. Contaminant concentrations between the NBCS and OGITS are decreasing. Treatment plant influent values for DIMP averaged approximately 900 µg/l after startup in 1993, then decreased to 33 µg/l in 2000, and to 22 µg/l in 2004. Mass removal estimates for the FYR period are presented in Table 7.2.2.1-1. The total mass removed during this FYR period was about 190 pounds. The table shows that five compounds (DIMP, dicyclopentadiene, chloroform, tetrachloroethylene and 4-chlorophenylmethyl sulfoxide) were each removed in quantities greater than 4 pounds, while the quantities for the remaining eight compounds were 0.5 pounds or less. The compound with the greatest mass removed was DIMP, for which a total of 162.6 pounds was removed. The total mass removed at OGITS in the previous FYR period was 472.5 pounds, of which DIMP accounted for 422.5 pounds. The volume treated during this FYR period was approximately 844,000,000 gallons which is higher than the volume of approximately 716,000,000 gallons treated during the previous review period. The reduction in mass removed is consistent with decreasing concentrations in the off-post areas upgradient of the First Creek and NPS.

Leaks in the piping system from the First Creek extraction system developed in 2003. The First Creek extraction and recharge system was shut down for repairs from February 23, 2003 to May 22, 2003 and the pipe was replaced. The impact of the extraction system shutdown due to the piping system leaks is evaluated in the 2003 OAR (PMRMA 2005b). It was concluded that due to significant precipitation and corresponding increases in water levels during the shut-off period, the gradients were reduced, resulting in reduced groundwater flow rates through the area. As detailed in the OAR, this led to the successful capture of all contaminated water that under normal circumstances would have migrated past the system during the period it was shut off.

The property on which the NPS is located has been acquired by Amber Homes, Inc whose plans for the property include the development of a large retail center and residential areas that entail construction at the NPS location. Based on discussions between Amber Homes, Army, and the regulatory agencies, agreement was reached on relocating the NPS to the Amber Homes property.

The modifications to the NPS affect the extraction system and the associated recharge wells used for reinjection of treated groundwater, as described in the Conceptual Design Document (Amber Homes, Inc, 2005). The original NPS and the modified system will be operated and monitored concurrently.

Four of the original NPS extraction wells, Wells NE7, NE 8, NE 9, and NE 10 (37811 through 37814), were shut off for hydraulic reasons in 2004 and three of these wells were abandoned to make room for the re-alignment of Peoria Street as part of the Amber Homes development. Appropriate ROD change documentation for the relocation of the NPS will be prepared. Two of the original First Creek extraction wells, Well FE4 (37803) and Well FE5 (37804) were shut off for hydraulic reasons in 2003.

Monitoring Wells 37009, 37010, 37008, 37012, and 37013, which are located immediately downgradient of the NPS and were sampled for water quality annually, showed long-term decreasing DIMP concentrations from 1992 to 2004. Water samples from all these wells were below the CSRG for DIMP during the period FY00 – FY04, except for Well 37009. Water samples from Well 37009, which is located at the northeast end of the system, exceeded the CSRG for DIMP from FY00 to FY02, and were below the CSRG in FY03 and FY04. Other analytes exceeded their CSRGs during the FYR period. Well 37013, located at the southwest end of the system, was above the chloroform CSRG of 6 μg/l in FY00, FY01, and FY02, but decreased to below the CSRG in FY03 and FY04. DBCP was above the CSRG in FY02, but decreased to below the CSRG in FY04. Tetrachloroethylene was above the CSRG in FY00 and FY02, but below the CSRG in FY01, FY03, and FY04. Well 37008 was just above the arsenic CSRG. Arsenic was reported above the CSRG in Well 32009 and 37013 in 2002, but the reported data likely were false positives. Both wells were below the CSRG in 2004. Fluoride concentrations in Well 37027, which is on the west side of the NPS system, exceeded the CSRG in 2004.

Monitoring Wells 37070, 37343, 37407, 37084, 37110, 37396, 37041, and private Wells 1185C and 1185B, which are downgradient of the First Creek pathway, showed decreasing long-term DIMP concentrations. Groundwater in these wells also showed a large decrease in DIMP concentrations during the FYR period. In Well 37343, which is downgradient of the center of the First Creek system, DIMP decreased from 11.3 μg/l in FY00 to below the CSRG during FY01 through FY04. In Well 37041 concentrations decreased from 100 μg/l in FY00 to 15.5 μg/l in FY04, and concentrations in Well 37070 were 38 μg/l in FY02 and 62 μg/l in FY04. Concentrations in private Well 1185C decreased from 50.7 μg/l in FY00 to below the CSRG in FY04, and private Well 1185B decreased from 39.4 μg/l in FY00 to 11.4 μg/l in FY 2004. Concentrations in Well 37407 were below the CSRG from FY 2001 through FY 2003 but were above the CSRG in FY04. DIMP concentrations decreased in Well 37084 from 270 μg/l in FY00 to 14.2 μg/l in FY04. Well 37110 decreased from 25 μg/l in FY00 to 8.01 μg/l in FY04, and Well 37396 showed a long-term decrease from 200 μg/l in 1994 to below the CSRG in FY00, FY03 and FY04.

It can be concluded that DIMP concentrations downgradient of the First Creek pathway have decreased significantly during the FYR period. However, review of the DIMP results obtained during the FYR period suggest that though DIMP concentrations may be decreasing on the west side of the First Creek system, they may be increasing slightly on the east side of the system. Well 37407, which shows an increased DIMP concentration in 2004, is in the First Creek paleochannel but east of the extraction wells. While the DIMP concentration was just above the CSRG in this well in 2004, overall, concentrations have decreased dramatically in this area.

During the FYR period some effluent samples from the OGITS showed exceedance of the CSRGs for arsenic and fluoride. Some of the arsenic analyses exceeded the CSRG during FY01 and FY02 and some of the fluoride analyses exceeded the CSRG during FY00. An evaluation of these exceedances found that the analytical methods used to analyze the fluoride and arsenic effluent samples did not provide the level of accuracy necessary for detecting these compounds at concentrations near the CSRG. As a result, the analytical methods were changed to methods that provide better accuracy at concentrations near the CSRG. The arsenic and fluoride exceedances did not occur after the analytical methods were changed.

Based on the assessment presented above, it can be concluded that OGITS is reducing the migration of contaminants in the alluvial channels intercepted and is, therefore, performing as intended in the Off-Post ROD. The beneficial impact of the OGITS on groundwater quality also is reflected in the reduction in contaminant plume sizes and concentration levels provided in the off-post exceedance maps. Clarifications of the performance objectives and criteria are needed to more effectively evaluate OGITS performance. Specific shut-off criteria and monitoring for this system will be evaluated as part of the revisions to the current LTMP.

7.2.2.2 Private Well Network #96

The Off-Post Private Well monitoring is conducted by TCHD for the Army. As described in Section 4.2.1.2, TCHD samples offpost private wells to provide data to refine the CSRG exceedance map, to determine the water quality of new offpost wells as required by the Off Post ROD, to respond to citizen requests, and to determine if CFS wells are acting a conduits for contaminant transport from the UFS to the CFS. Execution of the program depends on co-operation from the private well owners, and access to the wells is therefore not consistent. The 2000 FYRR and the *Well Networks Update for Well Retention and Closure, Water Year 2003* (Well Networks Update) (FWENC 2003a) incorporated off-post CFS wells 1070B, 343A, 359A, 486C, 588A, 589A, 848A and 914B into the LTMP network and included monitoring requirements for these wells. The *Well Networks Update for Well Retention and Closure, Water Year 2004* (TTFWI 2004l) revised the CFS Off-post Private Well Monitoring Network. Wells 1070B, 1171A, 359A, 376A, 544A, 545A, 548A, 848A, 914B and 986B are now included. Wells 343A and 486C are not in use and permission was not given for Wells 588A and 589A and for those reasons the wells could not be sampled and were therefore dropped from the network. Table 7.2.2.2-1 shows the results of DIMP and chloroform sampling from the offpost CFS private well network during the FY00 through FY04 review period.

7.2.2.3 Off-Post Institutional Controls #98

As discussed in Section 4.2.1.3, a recent review of permits issued in the notification area, TCHD found that:

- Over 90 permits had been issued in the notification area since the first RMA FYR. Most of the permits were for monitoring wells.
- The notification agreed to by the Army and the SEO in July 2001 was only found on three denied applications and on four well permits.
- The SEO does not appear to be following a standard procedure for transmitting copies of all well permits to the Army, EPA, and TCHD.

Despite the absence of notification, there was no known exposure to contaminated drinking water in wells installed in CSRG exceedance areas during the FYR period. As such the Off-Post ROD-stated objective of the Off-Post Institutional Controls, *"(p)revention of the use of the groundwater underlying areas of the Off-Post OU exceeding groundwater containment system remediation goals"* has been met and the project has effectively protected human health and the environment.

Based on the evaluation, TCHD has concluded, and RMA concurs, that the SEO is not including the agreed upon notification on all well permits issued in the notification area and copies of permits are not routinely being transmitted to all parties. For that reason, this topic will be identified as an issue in Section 8.

7.2.3 Other Operating Projects

7.2.3.1 Operation of Hazardous Waste Landfill Cells 1 and 2 #7

Based upon the status presented in 4.3.2.1, the HWL Cells 1 and 2 continue to operate and function as designed. The project is performing as expected and treatment is effective. The operating procedures, as implemented, are maintaining the effectiveness of the action and monitoring being performed is adequate. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. Opportunities for optimization are continually evaluated and a successful employee incentive program promotes that goal.

As noted in Section 4.3.2.1, DIMP was unexpectedly detected in the leak detection system of Cell 2 of the HWL. In response, ELF construction was modified to prohibit use of borrow materials along the old sanitary sewer line, the most likely source. The issue does not put remedy protectiveness at risk and the remedy is functioning as intended.

7.2.3.2 Operation of Hazardous Waste Landfill Wastewater Treatment Unit #10

Based upon the status presented in 4.3.2.2, the Operation of Hazardous Waste Landfill Wastewater Treatment Unit project continues to operate and function as designed. The project is performing as expected and containment is effective. The operating procedures, as implemented, are maintaining the effectiveness of the action and monitoring being performed is adequate. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. Opportunities for optimization are continually evaluated and a successful employee incentive program promotes that goal. No early indicators of potential issues have been identified.

7.2.3.3 Operation of Basin A Consolidation and Remediation Area #14

Based upon the status presented in 4.3.2.3, the Operation of Basin A Consolidation and Remediation Area continues to operate and function as designed. The project is performing as expected and containment is effective. The operating procedures, as implemented, are maintaining the effectiveness of the action and monitoring being performed is adequate. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors during construction. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. Opportunities for optimization are continually evaluated and a successful employee incentive program promotes that goal. No early indicators of potential issues have been identified. As noted in Section 4.3.2.3 Basin A capacity appears adequate to satisfy remedy needs.

7.2.3.4 Borrow Area Operations #47a

Based upon the status presented in 4.3.2.4, the Borrow Area Operations continues to operate and function as designed. The project is performing as expected. The operating procedures, as implemented, are maintaining the effectiveness of the action. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. Opportunities for optimization are continually evaluated and a successful employee incentive program promotes that goal. No early indicators of potential issues have been identified.

7.2.3.5 Site-Wide Biota Monitoring #48

Although included in Table 2.0-2 as an operating project, this subject matter was more appropriately addressed as a topic for data review in Section 6.4.3. Based upon the status presented in 6.4.3, the Site-Wide Biota Monitoring continues to operate and function as designed. The activity is performing as expected. The operating procedures, as implemented, are maintaining the effectiveness of the action and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

Long-term biomonitoring will continue to be conducted at RMA. Long-term biomonitoring is anticipated to be conducted in accordance with the *Long-Term Contaminant Biomonitoring Program for Terrestrial Ecological Receptors at Rocky Mountain Arsenal, Revision 0* (BAS 2006a). The long-term biomonitoring program was approved by Committee on January 11, 2007. The purpose of the long-term biomonitoring program is to help evaluate the efficacy of the remedy in accordance with the requirements of Section 9.7 of the ROD, i.e., that "monitoring activities for biota will continue by USFWS in support of evaluating the effectiveness of the selected remedy." The long-term biomonitoring program is anticipated to be implemented during the next FYR and the results from this program will be discussed in the next FYRR.

7.2.3.6 Site-Wide Air Monitoring #49

Although included in Table 2.0-2 as an operating project, this subject matter was more appropriately addressed as a topic for data review in Section 6.4.4. Based upon the status presented in 6.4.4, site-wide air and odor monitoring continues to operate and function as designed. The activity is performing as expected. The operating procedures, as implemented, are maintaining the effectiveness of the action and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

7.2.3.7 Site-Wide Surface Water Monitoring

Section 6.4.2 discusses the results of the surface water monitoring program. Section 6.4.2 references the report, *Surface Water-Quality and Water-Quantity from Selected Urban Runoff-Monitoring Sites at Rocky Mountain Arsenal* (USGS 2005), which was published by the USGS, and provides conclusions with respect to the storm water monitoring program at RMA. The Summary and Conclusions section of this report states, "(t)he existing surface water sampling program was not designed specifically to target storm runoff and therefore does not characterize water quality for all hydrologic regimes, most notably storm runoff. As a result, the existing data may not represent potential contaminant transport onto RMA." The Summary and Conclusions section goes on to state, "(t)hese types of transient runoff [i.e., storm] events make water quality sampling difficult, and none of the sites have a safe place to sample the highest flows that occur in any given year. As a result, most of the surface water quality samples were collected after the flow had decreased substantially from the peak flow, which may have transported much of the chemical contaminant load through the stream. Thus, the quality of the streamflow during the initial storm-water runoff period in the First Creek and Irondale Gulch Basins is not well characterized. In addition, brief periods of high concentrations of contaminants harmful to the health of the aquatic ecosystem could occur but go undetected with the existing twice-per-year sampling regime for surface water quality."

The *Surface Water Program Sampling and Analysis Plan* (FWENC 2001k)) states that storm event sampling is required for four upstream sites and two downstream sites at RMA. Two of these sites (SW24002 and SW24004) are identified in the RS/S (HLA 1996a) for surface water monitoring. While the conclusions discussed in the USGS report suggest that the adequacy of the storm event monitoring program and the representativeness of the storm event data that has been collected to date are questionable, it is important to note the context of these findings and to recognize that these same conclusions do not apply to the sites downstream from RMA.

The purpose of the USGS report (USGS 2005) was to provide a general characterization of the surface water quality and quantity at urban runoff sites for streams and stormwater conveyances that flow onto RMA from the Ironddale and First Creek drainage basins, which are respectively located south and southeast of the RMA. Much of the Irondale basin is urbanized with a high density of roads and the First Creek drainage basin is undergoing rapid urbanization. The finding of the report were made in the context that runoff from roads (including road salt) in urbanized areas is particularly episodic in nature with pulsed inputs when it rains or during more prolonged snowmelt periods.

The LTMP is scheduled to be revised in 2007 and modifications to the surface water monitoring program will be incorporated into the LTMP. The storm water monitoring component of the surface water program will be re-evaluated during this time based on the conclusions reached in the USGS report.

7.2.3.8 Site-Wide Groundwater Monitoring #50

Although included in Table 2.0-2 as an operating project, this subject matter is more appropriately addressed as a topic for data review in Section 6.4.1. Consistent with EPA guidance the issues will be summarized here and identified in Section 8.0.

Based on the data and discussions in Sections 4.1, 4.2 and 6.4 regarding the RMA groundwater monitoring program, the following issues have been identified.

- Because of large-scale development and construction activities in the Off-Post OU area, some Army monitoring wells have been destroyed and could not be re-drilled in the same locations. Changes to the off-post monitoring networks along with significant reductions in the extent of off-post contamination have resulted in a need to review and potentially revise the off-post exceedance monitoring network which was last updated in 2003.
- Evaluation of the effectiveness of the monitoring programs associated with the off-post and on-post treatment systems has indicated that there is a need to better define the performance objectives and wells used to determine the performance of the treatment systems.
- As described in Section 6.4.1, there were some deviations from the planned on-post and off-post water quality monitoring during the past FYR period, but these deviations were limited in number.

These issues with respect to the on-post and off-post monitoring networks highlight the need to revisit the LTMP.

7.2.3.9 Unexploded Ordnance Management #51

Based upon the status presented in 4.5.1.3, UXO Management continues to operate and function as designed. The activity is performing as expected and management of UXO and residuals is effective. The operating procedures, as implemented, are maintaining the effectiveness of the action and the monitoring being performed is adequate. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. Opportunities for optimization are continually evaluated and a successful employee incentive program promotes that goal. No early indicators of potential issues have been identified.

7.2.3.10 Medical Monitoring Program #52

Based upon the status presented in 4.5.1.4, the Medical Monitoring Program continues to operate and function as designed. The activity is performing as expected. The operating procedures, as implemented, are maintaining the effectiveness of the action and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

7.2.3.11 North of Basin F Groundwater Plume Remediation System #59

Based upon the status presented in 4.1.2.6, the North of Basin F Groundwater Plume Remediation System operated and functioned as designed and a CCR was prepared and approved by EPA on September 28, 2005. The project performed as expected and mass removal was effective. The operating procedures, as implemented, maintained the effectiveness of the action and monitoring was adequate. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed project, opportunities for optimization are not relevant. There are no early indicators of potential issues.

7.2.3.12 Operation of CERCLA Wastewater Treatment Facility #60

Based upon the status presented in 4.5.1.5, the CERCLA Wastewater Treatment Facility continues to function as designed. The project is performing as expected. The operating procedures, as implemented, are maintaining the effectiveness of the action. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. Opportunities for optimization are continually evaluated and a successful employee incentive program promotes that goal. No early indicators of potential issues have been identified.

7.2.3.13 Basin F Wastepile Operations and Management #65

As noted in Section 4.3.2.5, Cell 2 of the primary sump system is not operating as designed. Very little leachate is being collected in Cell 2 of the primary sump (leachate collection) system while larger volumes are being collected by the secondary sump (leak detection) system. There is no evidence the secondary system is leaking, but soils beneath the secondary sump will be monitored for staining during the Basin F Wastepile Excavation Project and reported in the CCR. It should be noted that the leachate and leak detection volume currently being generated (25,641 gallons in calendar year 2004) has now leveled off after consistently and dramatically declining from what it has been in the past (24,650 gallons in calendar year 1999, 81,336 gallons in calendar year 1990) due to the gradual dewatering of the waste.

Two possible causes for the performance of the Subcell #2 leachate collection systems have been identified. One possible cause is the Subcell #2 primary liner may have a significant breach which allows the entire leachate flow to be intercepted and diverted into the secondary leak detection system. The other possible cause is the Subcell #2 Primary Sump is clogged with salt crystals or fine soil particles, to the extent leachate can not flow into the sump for removal, allowing the leachate to pool on top of the primary liner until the leachate reaches to point of interconnection between the two systems, and flows into the secondary leak detection system.

As noted in Section 4.3.2.5, the clogging of the Subcell #2 Primary Sump, seems the more reasonable of the two possible causes for the leachate collection issues in Subcell #2. The RVO does not recommend any further investigation to determine the actual cause of the Subcell #2 leachate flow issue or ameliorative measures to restore leachate flow into the Subcell #2 for the following reasons since the Subcell #2 leak detection system is conveying leachate into the Subcell #2 secondary sump for removal. The On-Post ROD requires the Basin F Wastepile to be excavated and placed in a new triple-lined landfill, which was be ready to accept Basin F Wastepile waste in April 2006. The Basin F Wastepile design also includes a requirement to excavate any soil contaminated by leakage from the Basin F leachate collection and leakage detection system for subsequent disposal in the ELF.

During preparation of and resolution of comments on this FYRR, Basin F Wastepile remediation began, rendering the protectiveness of Basin F Wastepile O&M moot. For tracking purposes, it will continue to be included as an issue in Section 8 for closeout in the next FYRR.

7.3 Question A: Are the completed remedial actions functioning as intended by the decision documents

Each of the following projects have been completed in accordance with the On- or Off-Post ROD requirements and other change documentation and have been documented in a project-specific CCR. Evidence of compliance with the appropriate ROD is indicated in acceptance letters received from the EPA which state the following:

- Remedial action activities have completed all construction items identified in the Scope of Work and the Final Design Package, as modified, for these projects.
- The RVO has certified that the projects have been completed in accordance with the appropriate ROD.
- The State has concurred with the CCRs.
- The EPA has approved the CCR and accepted the projects as complete.

These completed projects were reviewed in more detail than were projects under construction. This reflects the added emphasis placed on completed ROD projects as stated in the EPA guidance on FYRs. Consistent with the EPA FYR Guidance (EPA 2001a) the following topics should be evaluated for completed projects:

Remedial Action Performance

Does the Remedial Action continue to be operating and functioning as designed?

Is the Remedial Action performing as expected and are cleanup levels are being achieved?

Is containment effective?

Systems Operations/O&M

Will operating procedures, as implemented, maintain the effectiveness of the response actions?

Do large variances in O&M costs indicate a potential remedy problem?

Is monitoring being performed and is it adequate to determine protectiveness and effectiveness of remedy?

Implementation of Institutional Controls and Other Measures

Are access controls in place and preventing exposure (e.g., fencing and warning signs)?

Are institutional controls in place and preventing exposure?

Are other actions (removals) to address immediate threats complete?

Opportunities for Optimization

Do opportunities exist to improve performance and/or costs of monitoring, sampling and treatment systems?

Early Indicators of Potential Issues

Do frequent equipment breakdowns or changes indicate a potential risk?

Could other issues or problems place protectiveness at risk?

7.3.1 Corrective Action Management Unit Soil Remediation Completion and Support #2

As noted in Section 4.3.3.1, the CAMU Soils Remediation Completion and Support Project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.2 Construct Hazardous Waste Landfill Wastewater Treatment Unit #3 and Construct Hazardous Waste Landfill Cell 1 #4

As noted in Section 4.3.3.2, the Construct Hazardous Waste Landfill Wastewater Treatment Unit and Construct Hazardous Waste Landfill Cell 1 projects have been completed and are protective. The facilities were constructed in accordance with the ROD, designs and other change documentation. As a facility construction project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of these facilities throughout operation and closure. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed construction project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.3 Section 26 Human Health Exceedance and Biota Exceedance Soils Removal #5

As noted in Section 4.3.3.3, the Section 26 HHE and Biota Soils project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant.

Subsequent to the project, it was noted that unbackfilled HHE excavations could pose a risk to biota. The issue was evaluated for all unbackfilled HHE excavation area and additional sampling and excavation was performed. As a result, that early indicator of potential remedy failure has been addressed and remedial action again functions as designed. The EPA approval of this additional excavation occurred after the March 31, 2005 cutoff date for the 2005 FYR; therefore, this project will also be included in the 2010 FYRR.

7.3.4 Construct the Hazardous Waste Landfill Cell 2 #6

As noted in Section 4.3.3.4, the Construct Hazardous Waste Landfill Cell 2 project has been completed and is protective. The facilities were constructed in accordance with the ROD, designs and other change documentation. As a facility construction project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of these facilities throughout operation and closure. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed construction project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.5 Shell Disposal Trenches Slurry Wall (construction) #17

As noted in Section 4.1.3.1, the Shell Disposal Trenches Slurry Wall (construction) project has been completed and is protective. The slurry wall was constructed in accordance with the ROD, designs and other change documentation. As a construction project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the Shell/Disposal Trenches throughout operation and closure. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed construction project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.6 Complex (Army) Disposal Trenches Slurry Wall (construction) #17

As noted in Section 4.3.3.5, the Complex (Army) Disposal Trenches Slurry Wall (construction) project has been completed and is protective. The slurry wall was constructed in accordance with the ROD, designs and other change documentation. As a construction project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the Shell/Disposal Trenches throughout operation and closure. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed construction project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.7 Post-ROD Removal Actions for Structures #18

As noted in Section 4.3.3.6, the Post-ROD Removal Actions for Structures project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an ACM abatement and pipe-draining project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed ACM abatement and pipe-draining project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.8 Toxic Storage Yards Soil Remediation #19

As noted in Section 4.3.3.7, the Toxic Storage Yards Soil Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.9 Existing (Sanitary) Landfills Remediation Section 1 #20

Subsequent to the project completed during the first FYR period, it was noted that unbackfilled HHE excavations could pose a risk to biota. The issue was evaluated for all unbackfilled HHE excavation areas and additional sampling and excavation was performed. As a result, that early indicator of potential remedy failure has been addressed and the remedial action again functions as designed. As noted in Section 4.3.3.8, the ESL Section 1 project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. The EPA approval of the additional excavation occurred after the March 31, 2005 cutoff date for the 2005 FYR; therefore, this project will also be included in the 2010 FYRR.

7.3.10 Existing (Sanitary) Landfills Remediation Section 4 #21

As noted in Section 4.3.3.9, the ESL Section 4 project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As an example of optimization, exploratory trenching resulted in a subsequent reduction in the volume of soil excavated was identified during field operations, tested and ultimately approved by the Regulatory Agencies. Early indicators of remedy failure were not identified.

7.3.11 Existing (Sanitary) Landfills Remediation Section 36 #22

As noted in Section 4.3.3.10, the ESL Section 36 project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.12 Lake Sediments Remediation #23

As noted in Section 4.3.3.11, the Lake Sediments Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant.

Subsequent to the project, it was noted that unbackfilled HHE excavations could pose a risk to biota. The issue was evaluated for all unbackfilled HHE excavation area and additional sampling and excavation was performed. As a result, that early indicator of potential remedy failure has been addressed and remedial action again functions as designed.

7.3.13 Burial Trenches Soil Remediation Part I and II #24

As noted in Section 4.3.3.12, the Burial Trenches Soil Remediation Part I and II project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

As noted in Section 4.3.3.12, thirty-four additional sites were added to the Burial Trenches Part I and Part II project during design or project implementation. The additional sites identified during design were inferred from the results of the Sanford Cohen and Associates geophysical survey of selected portions of RMA in 1998. These sites are in the general ROD-identified areas of UXO-related activity. The ROD anticipated the use of geophysical surveys to locate UXO. During implementation, the majority of the additional sites were discovered during revegetation activities of ROD-identified sites. However, these additional sites were investigated during the RI or FS and were not originally included in the ROD due to the absence of SEC exceedances. The sites were added to the project to remove miscellaneous and munitions debris and to confirm the RI and FS findings that MEC was not present at these sites. MEC was not observed during remediation of the additional project areas added as a result of revegetation activities. The addition of these sites during design and implementation evidences a functioning, iterative remedy process.

The CERCLA process recognizes the ROD as one step in a long sequence of remedy activities. As new data became available, the prior ROD conclusions were challenged and, where appropriate, the ROD conclusions were modified. As a result of the sites being added, this project, as implemented though the RI/FS, the ROD, the design evaluation, the design specifications, the site procedures and other change documentation, is functioning as intended.

7.3.14 Munitions (Testing) Soil Remediation Part I #25

As noted in Section 4.3.3.13, the Munitions (Testing) Soil Remediation Part 1 project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.15 Miscellaneous Northern Tier Soil Remediation #26

As noted in Section 4.3.3.14, the Miscellaneous Northern Tier Soil Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant.

Subsequent to the project, it was noted that unbackfilled HHE excavations could pose a risk to biota. The issue was evaluated for all unbackfilled HHE excavation areas and additional sampling and excavation was performed. As a result, that early indicator of potential remedy failure has been addressed and the remedial action again functions as designed. The EPA approval of this additional excavation occurred after the March 31, 2005 cutoff date for the 2005 FYR; therefore, this project will also be included in the 2010 FYRR.

7.3.16 Miscellaneous Southern Tier Soil Remediation #27

As noted in Section 4.3.3.15, the Miscellaneous Southern Tier Soil Remediation project has been completed and is protective with the exception of the Sand Creek Lateral Site SSA-2b and South Plants Ditches Site SSA-2a. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. With the exception of the unbackfilled HHE excavation areas and Sand Creek Lateral Site SSA-2b and South Plants Ditches Site SSA-2a, early indicators of potential remedy failure were not identified.

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. However, approved designs for Miscellaneous Southern Tier Soils (SSA-2a, SSA-2b and WSA-6a) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. However, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota. As indicated in Section 4.3.3.15, the BAS determined (USFWS 2002a) that the regrading and the small area of the sites resulted in acceptable risks to biota and no further action was required.

Subsequent to completion of the project, evaluation of soil data located at greater depths was performed. This effort identified soils exceeding acute Site Evaluation Criteria that, in the absence of additional institutional controls, warranted remediation. This soil was excavated and disposed in the HWL and additional sampling was performed. As a result, that early indicator of potential remedy failure has been addressed. The EPA approval of this additional excavation occurred after the March 31, 2005 cutoff date for the 2005 FYR; therefore, this project will also be included in the 2010 FYRR.

In addition, characterization of TRER soil led to discovery of contaminated soils associated with the historic operation of the Sand Creek Lateral. The issue was evaluated for all of Sand Creek Lateral and other ditches at RMA. As a result, that early indicator of remedy failure is being addressed and documented in an upcoming CCR, and the remedy is once again functioning as intended.

A portion of this additional contaminated soil was present within the Select Perimeter deletion area. The RI did not provide evidence to suggest that the banks were contaminated. In addition, during the original remediation, confirmatory samples collected from the final excavated surface had concentrations less than the exceedance levels, which provided no reason to believe that the banks of the SCL were contaminated beyond what had been excavated as CSV. Given the foregoing and without the benefit of the current aerial photographic library that was not nearly as complete at the time of the ROD, and in the absence of written documentation of dredging activities, there was no reason to suspect that the banks were contaminated. The CERCLA process allows for additional remediation if contamination is discovered within previous deleted areas. The discovery of additional contamination and the start of characterization of this area occurred during the 2005 FYR period.

The USFWS conducted visitation at RMA during the time period between when the original project was completed and the additional contamination was discovered. However, the visitation program was curtailed for part of this time during the Evaluation Team review of UXO and RCWM-related activities at RMA. In addition, once the visitation program was reestablished at RMA, visitation was restricted to the South Lakes area. USFWS is not aware of any excursion by visitors into the area of the additional contamination discovered along the SCL.

7.3.17 South Plants Structures Demolition and Removal Phase 1 and Phase 2 #29

As noted in Section 4.4.2.2, the South Plants Structures Demolition and Removal Phase 1 and Phase 2 project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As a demolition project, containment and O&M are not relevant, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed demolition project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.18 Miscellaneous RMA Structures Demolition and Removal Phase I #30

As noted in Section 4.4.2.3, the Miscellaneous RMA Structures Demolition and Removal Phase I has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As a demolition project, containment and O&M are not relevant, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed demolition project optimization is not relevant. Early indicators of remedy failure were not identified.

As noted in Section 4.4.2.3, and 4.5.1.3 the unexpected discovery of ten agent-filled bomblets during the course of the Miscellaneous Structures Demolition and Removal Phase 1 project required a significant, multi-faceted response. Based upon a review of that information, the remedy is once again functioning as intended.

7.3.19 Buried M-1 Pits Soil Remediation #31

As noted in Section 4.3.3.16, the Buried M-1 Pits Soil Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.20 Hex Pit Soil Remediation #32

As noted in Section 4.3.3.17, the Hex Pit Soil Remediation project has been completed and is protective. Based upon the ROD Amendment, the remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.21 South Plants Balance of Areas and Central Processing Area Soil Remediation Project Phase 1 #33

As noted in Section 4.3.3.18, the South Plants Balance of Areas and Central Processing Area Soil Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. The general RMA, Central Remediation Area, and project-specific exclusion boundary access controls as well as signage and activities controls, such as SafeRAC, protect the public from accessing this project where waste is left in placed. In addition, institutional controls exist to prevent exposure to the waste, such as prohibitions on excavation, drilling, tilling, grading, or construction of any sort other than actions taken as part of the remedy (PMRMA 2006a). As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.22 Secondary Basins Soil Remediation Phase I and II #37

As noted in Section 4.3.3.19, the Secondary Basins Soil Remediation Phase I and II project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.23 Section 35 Soil Remediation #41

As noted in Section 4.3.3.20, the Section 35 Soil Remediation project has been completed and is protective with the exception of the Sand Creek Lateral Site NCSA-5c and Miscellaneous Ditches Site NCSA-5b. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. With the exception of the Sand Creek Lateral Site NCSA-5c and Miscellaneous Ditches Site NCSA-5b, early indicators of potential remedy failure were not identified.

During project implementation, evaluation of soil data located at greater depths was performed. This effort identified soils exceeding acute Site Evaluation Criteria that, in the absence of additional institutional controls, warranted remediation. This soil was excavated and disposed in the HWL and additional sampling was performed. As a result, that early indicator of potential remedy failure has been addressed.

7.3.24 North Plants Structure Demolition and Removal #42

As noted in Section 4.4.2.4, the North Plants Structure Demolitions and Removal has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As a demolition project, containment and O&M are not relevant, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors.

Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed demolition project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.25 Western Tier Parcel (deletion) #53

As noted in Section 4.5.2.1, the Western Tier Parcel (deletion) is not a project tracked in the RDIS, but due to its importance at the time, it was included an "Other Project" in the past FYRR. To avoid confusion and to ensure that topics in the past FYRRs are closed out, the impacts of the changed land uses on exposure pathways resulting from the Western Tier Parcel (deletion) will be assessed in a general sense in Section 7.4.7.

7.3.26 Trust Fund #54

As noted in Section 4.5.2.2, good-faith best efforts to establish a trust fund for the remedy were made and were unsuccessful. This ROD requirement is closed and no further assessment is required.

7.3.27 Confined Flow System Well Closures #57

As noted in Section 4.1.3.1, the Confined Flow System Well Closures have been completed and remain protective. The remedial action continues to function as designed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.28 Irondale Containment System Main Wellfield Treatment (shutdown) #58

As noted in Section 4.1.3.2, the ICS (Main Wellfield Treatment System) project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. For this groundwater extraction and treatment project, containment and O&M are not relevant, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the Rail Classification Yard Treatment System. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA institutional controls (PMRMA 2006a) continues to satisfy the Refuge Act and ROD requirements. As a completed project optimization is not relevant. Early indicators of remedy failure were not identified.

7.4 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

There is one potential change to the assumptions used at the time of remedy selection that should be evaluated when determining whether the remedy remains protective. This is the discovery during the FYR period of the fuel contamination and associated LNAPL at North Plants.

This section also includes a discussion of all ARARs and TBCs identified in the RODs, and exposure and toxicity assessment variables and risk assessment methods used to develop soil cleanup criteria.

The ARARs are standards-based criteria, such as federal and state standards for soil, groundwater, or worker protection. ARARs can be chemical-specific, action-specific, or location-specific. TBCs are risk-based criteria established through risk assessments conducted for the relevant media and exposure pathways. The primary routes for potential exposure are consumption, dermal contact, and inhalation.

Included in this section are those ARARs and TBCs that have changed since the 2000 FYR. For those ARARs and TBCs that have changed, a determination has been made whether the change may impact the protectiveness of the remedy. Where this is the case, further discussion is provided. Conclusions and recommendations for further action are provided, as appropriate, in Sections 8.0 and 9.0 respectively. For organizational purposes, the ARARs and TBCs are separated into five categories; "water treatment system ARARs and TBCs," "worker exposure ARARs and TBCs," "air ARARs and TBCs," "soil ARARs and TBCs" and "other media ARARs and TBCs."

7.4.1 North Plants Fuel Release #42

LNAPL associated with groundwater was first delineated in the North Plants area in 2001 as part of the North Plants Groundwater Monitoring project (FWENC 2001m). During this time, a small amount of LNAPL was removed from Well 25055. During the North Plants Structure Demolition and Removal project, fuel-contaminated soil was encountered during sewer removal. That discovery triggered a series of characterization efforts designed to establish the extent of both soil contamination and LNAPL and is documented in Sections 4.4.2.4 and 6.4.1.2. The issue remains under evaluation and has been identified in Section 8.0.

7.4.2 Water Treatment System ARARs, TBCs, and PQL/MRLs

This section addresses ARARs, TBCs, and associated PQLs relevant to the water treatment systems that have changed as a result of the 2005 FYR. The ARAR, TBC and PQL/MRL changes addressed here will not be used to assess past system performance but will be considered for future application. Unless otherwise noted, the ARAR, TBC and PQL/MRL changes are adopted, as appropriate, by the FYR team with follow-up requirements documented in Section 9.

Water treatment ARARs were identified for the NWBCS, the NBCS, the OGITS, the BANCS, the CERCLA WWTU and the LWTU. The ARARs are based on state and federal standards as well as risk-based values. Potential changes in ARARs and TBCs for the different treatment systems are addressed in the following subsections.

7.4.2.1 PQLs, CRLs and MRLs

This section discusses the MRLs and PQLs and how they apply to the RMA treatment systems. To clarify the contents of this section, a few of the technical phrases are defined as follows:

- Practical Quantitation Limit – This limit is the lowest contaminant level at which a laboratory can assign a known precision and accuracy to the analytical results for a given analyte. Below this limit the precision and accuracy are uncertain. It is typically determined by a mathematical process incorporating data generated by an analytical method and the Method Detection Limit (MDL) (the lowest level that an analytical method can detect).

- Certified Reporting Limit (CRL) – Assigned by the decision document or ROD, a type of PQL determined based on a Army algorithm above which a method is expected to have a constant precision and accuracy. The CRL algorithm uses four sets of data.
- Method Reporting Limit - Also a type of PQL. The MRL is determined based on a slightly different Army algorithm using two sets of data. The MRL is also a limit above which a method is expected to have a constant precision and accuracy.

In cases where the ARAR or TBC could not be measured with the analytical methods available at the time, the ROD identified either CRLs or Colorado PQLs as the interim goals. It should be noted that this approach applies only to ARARs with values below the Colorado PQLs or Army-defined CRLs. In most cases, CRLs (rather than Colorado PQLs) were identified in place of the ARARs or TBCs that cannot typically be measured by available methods.

The On-Post ROD identifies the RMA-specific PQLs, described as "current certified reporting limit or practical quantitation limit readily available from a certified commercial laboratory," for 1,2-dichloroethane, carbon tetrachloride, aldrin, dieldrin, and NDMA for the NBCS and for dieldrin and NDMA for the NWBCS. The On-Post ROD states that the PQLs for 1,2 dichloroethane, carbon tetrachloride, and dieldrin at the BANCS are "current practical quantitation limits or certified reporting limits".

The Off-Post ROD identifies "PQL attainable by the U.S. Army" (i.e., the CRLs) for aldrin, dieldrin, chlordane and carbon tetrachloride and the PQL for 1,2-dichloroethane as the "PQL listed in the CBSG standards" (i.e., the Colorado PQL). It should be noted that the State of Colorado PQLs are in the process of being revised but the values presented in the 2005 PQL guidance continue to apply as TBCs..

Since the On-Post and Off-Post RODs were signed, the MRL has replaced the CRL as the official laboratory reporting limit used at RMA for the Army methods currently being used to analyze RMA groundwater. The MRL is determined based on a slightly different Army algorithm than that used for the CRL, and is a limit above which a method is expected to have a constant precision and accuracy. It should be noted that, from a statistical reliability standpoint, there is no difference between the MRLs and the CRLs, and the ability of the Army to quantify contaminants in samples has in no way been compromised by the switch to MRLs. MRLs are generally equivalent with "industry" standards, and procedures for MRL determination are identified in Appendix A of the RMA Chemical Quality Assurance Plan (PMRMA 2004).

For all constituents where the PQLs or MRLs were or are above the corresponding regulatory limit, Table 7.4.1.1-1 summarizes the initial (per the On-Post and Off-Post RODs), PQL changes that have occurred during the FYR period, and the current (2004) PQLs that apply at each of the water treatment systems. It should be noted that for the BANCS, different and slightly higher quantitation limits have historically been used (e.g., PQL for 1,2-dichloroethane = 1.1 µg/l). The PQL changes since the past FYRR can be summarized as follows:

- The MRL for 1,2-dichloroethane has been lower than the CSRG since before 2000, so this compound is not included for NBCS and OGITS in the PQL table.
- There has been an increase in the MRL for aldrin, which applies to NBCS and OGITS, from 0.025 µg/l in 2000 to 0.037 µg/l in 2004, so the current PQL for aldrin is 0.037 µg/l.

The Regulatory Agencies were notified of the change in the aldrin PQL in a letter issued October 12, 2004. This notification, which was done in accordance with the process established in the 2000 FYRR, effectively changed the PQL to 0.037 μg/l. The MRL fluctuation for this method is standard variability of the data and does not reflect degradation of method performance. The laboratory continues to try to achieve lower MRLs.

Although the 2005 quantitation limit for carbon tetrachloride listed in Table 7.4.1.1-1 is above the 2005 CSRG, progress was being made at the end of this FYR period to meet the carbon tetrachloride CSRG. As of January 2006, the carbon tetrachloride MRL is below the CSRG. Decision document DD-RMAPQL-11, signed on October 26, 2006, presents the January 2006 reporting level of to 0.2 μg/l for carbon tetrachloride, which is below the CSRG of 0.27 μg/l.

Reductions in both the dieldrin and aldrin MRLs were achieved in January 2005, but since fluctuations have previously occurred, it was decided to use a standardized approach for redefining the PQLs rather than react to method variations.

In the 2000 RMA FYRR, a procedure was defined to ensure that new quantitation limits would be implemented in a timely and consistent manner. The quantitative values associated with the MRLs are defined by the procedures in Appendix A of the RMA Chemical Quality Assurance Plan, and depend on the availability of contract laboratories as well as the ability of these laboratories to maintain their method detection and reporting limits. The selection of a new MRL depends on the following three factors:

- The establishment of new MRLs by various laboratories under contract to RMA
- The reliability of the established MRL being considered reproducible over the upcoming FYR cycle
- The professional judgment of the FYR Team conducting the review

In addition, the 2000 FYRR states, "(a)fter the MRLs and PQLs have been redefined in the FYRR, it is conceivable that changes could occur in these quantitation limits due to laboratory changes, method changes, or other events. The MRLs may vary whenever a new laboratory is put under contract, or whenever a laboratory under current contract conducts proficiency testing (required once every three years) to redefine its operating parameters. In the event that lower quantitation limits become available, adoption of these limits will be considered during the next FYR. In the event that quantitation limits change, a letter will be sent by the Army to the EPA, CDPHE, and TCHD notifying them of the change and proposing action. As has been the case in the past in obtaining analytical services, laboratories will be required to meet ROD-specified quantification limits. In the event that an analytical method change is proposed, a letter also will be sent by Army to EPA, CDPHE, and TCHD prior to adopting the new method notifying them of the proposed change and the anticipated impact on PQLs."

In the ongoing effort to achieve the stated CSRGs for those chemical constituents that historical laboratory capabilities have been unable to attain, the laboratory management team continues to evaluate emerging technologies. This effort is conducted on the following fronts:

- The laboratory support program requires recertification of those methods whose proficiency demonstrations are greater than three years old and the method performance could be expected to change. Reasons for an expected method performance change include: changes to the reference methodology that would alter or improve the methods ability to detect and quantitate at lower levels, or laboratory procurement of newer, more technologically advanced instrumentation.

- The laboratory support team continues to keep abreast of advancements made in technology and methodology that may be useful in lowering reporting levels or allowing Army to achieve the CSRG levels. The laboratory support team relies on analytical professionals at the on-site laboratory, as well as professionals at the off-site contract laboratories to identify where advances in instrumentation and methodology have been made and how best to make effective use of them.
- New methodologies considered for RMA are evaluated based on commercial availability of the necessary equipment,
- Laboratories performing analytical work for RMA must be able to meet the stringent QA/QC requirements of the program as well as deliverable requirements.
- The laboratory support program is making efforts to review publications and involve laboratories where specific methods have been developed for constituents of interest for which the MRLs exceed the PQL. In the case of NDMA, significant progress has been made in lowering the detection limits for drinking water.

The use of MRLs as site-specific PQLs that are being used as default CSRGs has raised concerns during this FYR period. The increase in the aldrin MRL illustrates how normal fluctuations in laboratory data can affect the PQL when it is set at the reporting level. PQLs set at the reporting level also result in method sensitivity issues and errors. For these reasons, the existing process for determining PQLs/MRLs has been identified as an issue. The recent advancements in analytical technology suggest that lower PQLs may be achievable over time. The PQL approach will be included as an issue in Section 8. During the comment resolution process on the 2005 FYRR a decision document, DD-RMAPQL-11, outlined the process and procedures for determining site-specific PQLs.

7.4.2.2 ARARs

Northwest Boundary Containment System

The ARARs for the NWBCS were defined in Table A-3 in the On-Post ROD. The compounds for which ARARs were identified are based on the CSRG list presented in Table 9.1-1 in the same document. There have been only two changes in state standards that could affect ARARs and consequently NWBCS CSRGs. This change is listed in Table 7.4.1.2-1.

A change in the CSRGs to the new CBSGs for chloroform and NDMA is recommended. The NWBCS currently includes carbon adsorption for treatment of organics, including chloroform. While it may be difficult to treat low levels of chloroform with carbon adsorption, the current treatment system is expected to be able to meet the new standard and continue to be protective of human health and the environment. The reduction in the standard for NDMA is not likely to affect protectiveness because no NDMA has been detected in this part of RMA, no consumption of groundwater is occurring and the current PQL is within the EPA acceptable risk range of 10^{-4} to 10^{-6}. As discussed in this FYRR, site-specific PQL studies will be conducted to determine the PQL for NDMA. If that PQL is lower than the ROD-identified and current PQL of 0.033 µg/l, the groundwater at the NWBCS should be analyzed to determine if NDMA is present at or above the new PQL. The change in ARARs at the NWBCS is not an issue because there is no anticipated change in being able to meet the discharge standard for chloroform, and the need to conduct a site-specific PQL study for NDMA has been identified elsewhere.

North Boundary Containment System

The ARARs for the NBCS were defined in Table A-5 in the On-Post ROD. The compounds for which ARARs were identified are based on the CSRG list presented in Table 9.1-3 in the same document. There have been five changes in state standards that could affect ARARs and consequently NBCS CSRGs. These changes, along with explanations of nature of the changes, are listed in Table 7.4.1.2-2.

A change in the CSRGs to the new CBSGs for carbon tetrachloride, chloroform, 1,2 dichloroethane, methylene chloride, and NDMA is recommended. The NBCS currently includes carbon adsorption for treatment of VOCs and ultraviolet oxidation for treatment of NDMA. Therefore, the current treatment system is expected to be able to treat the VOCs to the new standards and continue to be protective of human health and the environment. The reduction in the standard for NDMA is not likely to affect protectiveness because no consumption of groundwater is occurring and the current PQL is within the EPA acceptable risk range of 10^{-4} to 10^{-6}. As discussed in this FYRR, site-specific PQL studies will be conducted to determine the PQL for NDMA. The change in ARARs at the NBCS is not an issue because there is no anticipated change in being able to meet the discharge standard for VOCs, and the need to conduct a site-specific PQL study for NDMA has been identified elsewhere.

Off-Post Groundwater Intercept and Treatment System

The ARARs for the OGITS were described in Section 10.1.2 of the Off-Post ROD. The compounds for which ARARs were applied as CSRGs are identified in Table 7.1 in the same document. There have been only five changes instate standards that will affect ARARS and consequently OGITS CSRGs. The changes are listed in Table 7.4.1.2-3.

A change in the CSRGs to the new CBSG for carbon tetrachloride, chlordane, chloroform, 1,2-dichloroethane and NDMA is recommended. The OGITS currently includes carbon adsorption for treatment of VOCs and OCPs. Therefore, the current treatment system is expected to be able to treat the VOCs and OCPs to the new standards and continue to be protective of human health and the environment. The reduction in the standard for NDMA is not likely to affect protectiveness because there is no consumption of groundwater and the current PQL is within the EPA acceptable risk range of 10^{-4} to 10^{-6}. As discussed in this FYRR, site-specific PQL studies will be conducted to determine the PQL for NDMA. The change in ARARs at the OGITS is not an issue because there is no anticipated change in being able to meet the discharge standard for chloroform, and the need to conduct a site-specific PQL study for NDMA has been identified elsewhere.

Basin A Neck Containment System

The ARARs for the BANCS were defined in Table A-6 in the On-Post ROD. The compounds for which ARARs were identified are based on the CSRG list presented in Table 9.1-4 in the same document. There have been four changes in state standards that could affect ARARs and consequently BANCS CSRGs. These changes are listed in Table 7.4.1.2-4.

A change in the CSRGs to the new CBSG for carbon tetrachloride, chloroform, 1,2-dichloroethane and hexachlorocyclopentadiene is recommended. The BANCS currently includes air stripping and activated carbon adsorption for treatment of VOCs and OCPs. Therefore, the current treatment system is expected to be able to treat the VOCs and OCPs to the new standards and continue to be protective of human health and the environment. The change in ARARs at the BANCS is not an issue because there is no anticipated change in being able to meet the discharge standards for VOCs and OCPs.

<u>CERCLA Wastewater Treatment Unit</u>

The ARARs for the CERCLA WWTU were defined in Appendix I of Element One of the CERCLA Hazardous Wastes IRA (Weston 1992). One change at the CERCLA WWTU deserves note. At the time the IRA was issued, the CERCLA WWTU plan was to discharge the treated effluent to the on-site sewage treatment plant. Instead, during construction of the CERCLA WWTU, it was decided to reinject the treated effluent at the BANCS reinjection gallery. Discharge to the on-site sewage treatment plant only occurred infrequently when the capacity of the BANCS reinjection gallery was insufficient.

To align the CERCLA WWTU standards with the reinjection at the BANCS, a rationale consistent with that originally used to set standards at BANCS has been employed. As a result, there have been fourteen changes in CERCLA WWTU standards identified as necessary for alignment. These changes are listed in Table 7.4.1.2-5.

The above changes to the CSRGs are recommended. The CERCLA WWTU currently includes air stripping, activated carbon adsorption, and/or UV oxidation for treatment of VOCs, OCPs, and DIMP. Therefore, the current treatment system is expected to be able to treat the VOCs, OCPs, and DIMP to the new standards and continue to be protective of human health and the environment. The change in ARARs at the CERCLA WWTU is not an issue, because there is no anticipated change in being able to meet the discharge standards for VOCs, OCPs, and DIMP.

<u>Landfill Wastewater Treatment Unit</u>

The ARARs for the CERCLA WWTU were defined in the LWTU ARARs Compliance and Discharge Control Mechanism Document (EPA 2002a). There have been 35 changes in state standards that could affect ARARs and, consequently the LWTU CSRGs. These changes are listed in Table 7.4.1.2-6. There were no changes to the Daily Maximum (Acute) limits for the LWTU. The above changes to the CSRGs are recommended and discussed in Section 4.3.2.2.

The LWTU discharges into a ditch leading to First Creek. The discharge flow has not been observed to actually reach First Creek. First Creek is not classified as drinking water source and it is not used as a drinking water source. First Creek flows into Burlington ditch. Burlington ditch is not classified for drinking water use and is not used as a drinking water source. In fact, the nearest downstream location classified for drinking water use is Barr Lake. Although not currently a drinking water source, that classification was assigned to Barr Lake because drinking water wells are in operation downstream of Barr Lake. As relevant and appropriate requirements, several of the LWTU CSRGs have been based on drinking water use because of the Barr Lake drinking water classification. Even though several of the LWTU CSRGs are below current detection limits, the actual exposure point for drinking water consumption is removed by many miles and many steps that will attenuate the already low detection limit concentrations. For that reason, despite LWTU CSRGs being below detection limits, in the absence of any existing or likely exposure, the remedy remains protective.

During preparation of and response to comments on this FYRR, the LWTS CCD was updated to account for additional constituents that may require treatment as a result of Basin F Wastepile wastes being placed into the ELF. The revised CDD will be assessed in the next FYR.

7.4.2.3 Groundwater TBCs

There were no reported changes to groundwater TBCs.

7.4.3 Worker Exposure ARARs and TBCs

Several worker exposure ARARs and TBCs changed since the past FYR. Eleven ARARs or TBCs were deemed to affect the protectiveness of workers at RMA. All mandatory changes were immediately adopted and non-mandatory changes were considered and adopted where appropriate. These changes are detailed in Tables 7.4.2-1 and 7.4.2-2.

7.4.4 Air ARARs and TBCs

No air ARAR changes were identified over the FYR period that affected the protectiveness of the RMA remedy. The TBCs for the RMA site-wide air criteria are updated, agreed upon and adopted yearly in the Interactive Comprehensive Air Pathway Analysis. During the FYR period, changes to the TBCs for the chronic carcinogenic and chronic noncarcinogenic criteria were noted. No TBC changes were noted for the acute air criteria.

For the chronic carcinogenic criteria, updates to cancer slope factors published in Integrated Risk Information System and toxicity values documented by EPA Region 3 have resulted in changes to the TBC-based air criteria for two chemicals. For the chronic, noncarcinogenic criteria, updates to the inhalation reference doses and reference concentration as documented in Integrated Risk Information System have resulted in changes to the TBC-based air criteria for eight chemicals. These changes are listed in Table 7.4.3-1.

7.4.4.1 TSP as Surrogate to Confirm Acceptable PM-10 Levels

For eight years, the Army has successfully controlled dust emissions, including PM-10, during implementation of the remedy through use of rigorous control processes. Future remediation activities are similar to those already completed, and the same rigorous control processes are expected to be implemented. Therefore, in order to use air monitoring resources more efficiently, RVO proposed to use existing TSP monitoring as a surrogate measurement to confirm acceptable PM-10 levels. During preparation of and comment resolution on the 2005 FYRR, the above proposal was agreed upon by all parties and documented in a RMA Decision Document dated April 19, 2006 (PMRMA 2006c).

7.4.5 Soil ARARs and TBCs

This section addresses ARARs and TBCs for soil remedies. No changes to chemical-specific ARARs for soils were noted. Similarly, no changes to risk-based chemical specific TBCs (e.g., Cancer Potency Factors of Reference Doses in the Integrated Risk Information System for RMA soil COCs were noted.

Since the ROD was signed there have been significant efforts to identify and remedy soils presenting RERs. A summary of these efforts is presented in Section 6.3.2 and below.

7.4.5.1 Identification of Residual Ecological Risk Soil

As required by the ROD, the BAS was tasked with determining a level of acceptable risk to biota remaining after implementation of the ROD-prescribed remedial activities. To better assess residual risk, the BAS used results of the Supplemental Field Study Phase 1 (FWENC 1996b) to narrow its focus. The Supplemental Field Study concluded that while risks to mammals were overestimated in the Integrated Endangerment Assessment/Risk Characterization, risks to small birds were underestimated. The premise was made that if small birds were adequately protected, it could be reasonably defended that all other terrestrial receptors would be adequately protected. The Supplemental Field Study results also indicated that approximately 90 percent of the risk to the small bird receptor was caused by exposure to combined aldrin and dieldrin, termed todrin. This allowed future risk assessment efforts to focus on the small bird exposure to todrin.

An initial assessment of risk to small birds, completed in early 1997, used an adjusted biomagnification factor from Supplemental Field Study results, and identified two classes of soil areas that exhibited generally higher and lower risks. The BAS ranked the higher risk areas P1 soil and the lower risk areas P2 soil. These areas were defined using aldrin, dieldrin and arsenic soil concentration data, interpolated grids of estimated soil concentrations for todrin, and todrin beetle tissue data from the Supplemental Field Study.

The BAS, working in coordination with the Borrow Committee, developed the concept that removing the soil in the higher risk areas would effectively eliminate risk in those areas, and refined the Borrow Areas to incorporate P1 soils as much as practicable. This initial effort concluded with a BAS recommendation to the RMA Committee that the higher risk, or P1, soil areas should have priority for surface soil (0 to1 foot) removal in order to maximize risk reduction for biota. The RMA Committee subsequently signed an agreement in May 1997 (PMRMA 1997b) detailing the design refinements for surficial soil excavation and related risk reduction. This agreement committed to the removal of the identified P1 soil areas (approximately 997 acres) and detailed requirements for use as borrow soil. The ROD requirement to refine the areas of excess risk was addressed, in part, by this agreement and incorporation of P1 soil removal in the Borrow Areas Plan.

7.4.5.2 Terrestrial Residual Ecological Risk Report

Following initial identification of P1 and P2 soils and incorporation of P1 soil removal in the remedy, the BAS continued to evaluate potential residual risks in order to complete the ROD requirements for residual risk evaluation. The continued evaluation included P2 soil areas since they were not required for removal under the 1997 agreement. Ultimately the "P2 soils" nomenclature was subsumed under the title TRER. The terrestrial portion of the risk assessment was finalized in April 2002 (BAS 2002) and an addendum to the report was issued in April 2003 (BAS 2003a). The TRER report summarizes the results of the study and identifies areas and amounts of potential residual risk, identifies options for reducing those residual risks and identifies areas that are candidates for possible future monitoring.

The TRER report established soil biota criteria for total aldrin/dieldrin (todrin) to determine an action level threshold. A todrin concentration of 65 parts per billion represents a HQ of 1. Residual risks to terrestrial wildlife were estimated using the small bird as the key receptor. A modeled HQ value represents the average risk over the small bird's home range (approximately 2.88 acres). Sites with an HQ ≤ 2 are considered acceptable risk and no remedial action is necessary.

The study used a tiered approach to identify the magnitude and extent of RERs. Initially, 60 areas were identified with potential elevated residual risk to biota based on estimated soil concentrations. After additional soil sampling in 24 areas and further evaluation, it was determined that 18 of the areas had acceptable risk. There remained 42 TRER sites with potentially elevated risk that required remediation. The BAS provided recommendations for remediating these areas in the 2003 RMA Committee Agreement (PMRMA 2003e).

The Agreement provided removal or tilling of the 42 TRER sites. Twenty-four of the areas are located primarily in or adjacent to BAs. For these areas, removal is the preferred remedial approach. However, if the soil will not be removed, soil tilling can be substituted to reduce risk to acceptable levels. The tilling method approved by the BAS consists of 3 steps, 1) ripping to 18 inches, 2) plowing to 12 inches and, 3) discing to 6 inches. The remaining 18 areas are outside BAs and the Agreement states that the 3-step tilling process is the preferred approach to reduce risk to acceptable levels.

The BAS assessment of RER concluded that only acceptable TRERs will remain after the completion of ROD remedial actions, removal of P1 soil, and removal or tilling/revegetation of TRER sites. This fulfilled the ROD requirement to further refine the areas of surficial soil to be remediated. Per BAS recommendations, both P1 and TRER soil remediation are being tracked by the annual Borrow Area Management Plan (TTECI 2005e) updates.

Until the 2003 RMA Committee Agreement, there was no requirement for a CCR or similar report to document P1 and TRER soil removal. The agreement prior to 2003 was that P1 Soil removal would be documented yearly in Borrow Area Management Plan updates. The 2003 Committee Agreement added a requirement at the completion of all RER soil actions to prepare a "CCR-like" document which referenced all prior Borrow Updates to show completion of RER actions. The "CCR-like" document was approved by EPA on March 30, 2006 (TTECI 2006i).

Based upon this CCR-like document, a summary of the results of the TRER remediation will be presented in the next FYR.

7.4.6 Other Media ARARs and TBCs

This section addresses ARARs and TBCs for all other "Chemical-Specific," "Location-Specific" and "Action-Specific" requirements beyond those listed in Sections 7.2.1 through 7.2.4 above. No other ARAR changes were identified that could potentially affect the protectiveness of the remedy.

7.4.7 Changes in Exposure Assessment Variables

The demographics and associated exposure scenarios considered in the On-Post and Off-Post OU have not changed significantly since the signing of the RODs. The physical characteristics of the site (climate, vegetation, hydrology, and surface water) have remained relatively unchanged. Populations on and near the site have not changed significantly. Activity patterns and the presence of sensitive subpopulations have likewise not changed notably. While residential land development has occurred north of RMA during the FYR period, this does not alter the exposure scenario assumptions made in the RODs.

During this FYR, the Western Tier Parcel and the Select Perimeter and Surface Deletion Areas have been deleted from the NPL. Property use in the Western Tier is anticipated to be for rights-of-way and commercial use, including, possibly, a day-care facility. The results of additional vapor-phase transport evaluation, surficial soil data evaluation, dioxin characterization, and O/E and RCWM hazard evaluation indicated that the area was suitable for commercial use, including a day-care facility (PMRMA 2002d). The primary RMA-wide institutional controls, such as prohibitions on residential development, remain in force. Based on the foregoing, the exposure assumptions at the time of the ROD remain valid.

The Select Perimeter and Surface Deletion Area property were transferred to the USFWS in 2004 and the USFWS established the Rocky Mountain Arsenal National Wildlife Refuge in 2004. Use of the property as a wildlife refuge was anticipated and does not require a change in the exposure assessment assumptions.

Exposure pathways were evaluated for contaminants in both OUs. The mechanisms of release in the On-Post OU have not changed while, in the Off-Post OU, one of the primary exposure pathways has been eliminated by the implementation of various off-post institutional controls (to include municipal water hookups of off-post residences). As noted in the 2000 FYRR, the CDPHE prepared a risk assessment to evaluate the public health significance of consuming vegetables and fruits irrigated with DIMP-contaminated groundwater. The assessment concluded that the risk associated with exposure to DIMP at concentrations at or near the state groundwater standard is unlikely to be a public health concern.

During this FYR period, an assessment of vapor intrusion from contaminated groundwater in the Off-Post Operable Unit was conducted. The assessment used site-specific information about off-post groundwater concentrations and subsurface conditions to estimate potential indoor air concentrations and associated human health risks. The assessment was conducted consistent with EPA's draft vapor intrusion guidance (EPA 2002b) using the residential scenario. The evaluation indicated that site-specific risks were below the screening levels and that no further evaluation was necessary (EPA 2004).

Monitoring data as described in this report indicate that no adverse changes in exposure concentrations were discovered. In most cases concentrations have generally decreased, resulting in less risk over time. In the On-Post OU this can be primarily attributed to the removal of source areas while in the Off-Post OU this can be attributed to natural attenuation.

Overall there is no reason to conclude that contaminant intake has increased in any of the scenarios originally evaluated in the selection of the remedy.

7.4.8 Changes in Toxicity Assessment Variables

No evidence was found of any substantive changes in toxicity values used in the determination of an acceptable remedy.

7.4.9 Changes in Risk Assessment Methods

There were no changes in risk assessment methods that would require revision of the original risk assessment work.

7.5 Question C: Has any other new information come to light that could call into question the protectiveness of the remedy?

Besides information discussed above in Questions A and B, no other new information has come to light during this FYR that calls into question the protectiveness of the Remedy.

7.6 Technical Assessment Summary

According to the data reviewed, the documents reviewed and the site inspections, the remedy is functioning as intended by the ROD and as modified by the ROD amendments, ESDs and other administrative changes. There have been no changes in the physical conditions of the site that would affect current or future protectiveness of the remedy. Risk-based Site Evaluation Criteria for soil presented in the ROD are being met. There have been no changes in the toxicity factors for the COCs that were used in the baseline risk assessment, and there have been no changes to the standardized risk assessment methodology that could affect the protectiveness of the remedy. There is no other information that calls into question the protectiveness of the remedy.

8.0 ISSUES

Section 8.0 presents the issues identified during the technical assessment or other FYR activities. As noted in Section 7.6 and Table 8.0-1, none of the issues directly affect current or future protectiveness. In addition, Section 8.14 discusses unresolved concerns raised by regulatory agencies and the community.

8.1 Basin F Wastepile

The Basin F Wastepile is not operating as designed, as detailed in Section 7.1.8. Very little leachate is being collected in the primary system (leachate collection) of Cell #2 while larger volumes are collected by the secondary sump (leak detection) system. There is no evidence that the secondary sump system in Cell #2 is leaking, but soils beneath the secondary sump system will be monitored for staining during the Basin F Wastepile Excavation Project and reported in the CCR. Cells #1 and #3 are operating as expected. It should be noted that leachate volume currently being generated is dramatically less than it has been in the past due to the gradual dewatering of the waste. For those reasons, the issue is not affecting current protectiveness of the remedy. Follow-up is provided in Section 9.1.

8.2 Monitoring Well Maintenance and Security

During FYR inspections, the team found that four monitoring wells, located off-post east of the North Gate access to RMA and just outside the relocated RMA perimeter fenceline were found to be damaged and had not been fixed or replaced in a timely manner. Two of these wells were "orphan" wells that are not included in the current database. The primary reason these monitoring wells were not locked was that the recent fence relocation resulted in on-post wells (for which locks are not required) being located outside the secured perimeter fence. In addition, three other wells were identified which had previously been flagged in the database as requiring repair. Of the three wells, one was closed and replaced by a new well and the other two were repaired. The Army had scheduled these wells for repair prior to the FYR inspections and the repairs were completed after the site inspection was conducted. It is Army policy to lock all monitoring wells located outside the RMA perimeter fence, or outside off-post fenced-in well fields. Also, the Well Retention and Closure Program (FWENC 2003j) requires prompt notification and response for damaged wells and in this case response was delayed. This issue did not affect the protectiveness of the remedy. Follow-up is provided in Section 9.2.

8.3 Extraction Well and Extraction System Shut-Off Criteria

During the evaluation of how ROD shut-off criteria had been applied to past and planned extraction well and system shut-off, it became apparent that the existing ROD criteria leave room for interpretation. Two questions were identified related to the ROD shut-off criteria:

- When can a well be turned off for hydraulic purposes; can this apply when the well has already met chemical shut-off criteria?
- How long after an extraction well has been turned off for chemical purposes should shut-off monitoring start? (The ROD does not identify a timeframe for this action).

The possible different interpretations of the ROD shut-off criteria have not affected the shut-off process during the past FYR period. Follow-up is provided in Section 9.3.

8.4 Establishing Site-Specific PQLs

The On-Post ROD identifies the site-specific PQL as "(c)urrent certified reporting limit or practical quantitation limit readily available from a commercial laboratory." Consistent with the assessment presented in Section 7.4.2, the existing process for determining PQLs/MRLs has been identified as an issue for the compounds for which the PQLs remain above the CSRGs in part because Army has used an MRL-based approach which differs from industry practice. The ongoing changes to the RMA analytical programs and recent advancements in analytical technology suggest that it would be beneficial to follow a standardized procedure to evaluate the analytical capabilities of several laboratories. Therefore, it has been determined necessary, during the next FYR period, to re-evaluate the current laboratory procedures and the procedure for establishing site-specific PQLs.

Institutional controls are in place to prevent exposure until the CSRG/CBSGs are attained. The groundwater remedy as it currently exists is therefore protective. Follow-up is provided in Section 9.4.

8.5 Bedrock Ridge Plume Capture

As stated in the Section 7.1.4 assessment, it was determined that a low volume of the Bedrock Ridge plume was not captured by the extraction system. To ensure that the ROD objective for this system was met, it was decided that the addition of an extraction well should be evaluated and tested. The additional extraction well was installed and its performance will be evaluated during the next FYR period.

While the need to improve plume capture was identified for the Bedrock Ridge system, the low volume of bypass did not affect remedy protectiveness due to site-wide remedy elements including downgradient groundwater treatment systems and institutional controls. Follow-up is provided in Section 9.5.

8.6 Shell Disposal Trenches Dewatering Goals

As noted in the status in Section 4.1.2.1, the ROD remedy for the Shell Disposal Trenches is described as "installing a soil cover and slurry wall to reduce movement of contaminants from the Shell Disposal Trenches in Section 36." Consistent with the assessment presented in Section 7.2.1.1, the dewatering goal of achieving water levels below the bottom of the trenches had not been met at the end of the FYR period. The fact that water level measurements were not collected from the monitoring wells inside the slurry wall during a portion the FYR period makes it difficult to verify that the remedy was functioning as intended. However, there is no impact to protectiveness due to site-wide remedy elements including downgradient treatment systems and institutional controls. Follow-up is provided in Section 9.6.

8.7 South Lakes Plume Management

As noted in Section 7.2.1.7, the 2004 South Lakes Groundwater Monitoring Report concluded that there was no migration of contaminants into the South Lakes at levels exceeding CBSGs, and consequently, the goal of preventing the migration of contaminants into the South Lakes at levels exceeding the CBSGs has been met. As a result, the parties agreed that it was appropriate to remove the lake level maintenance requirement from the selected remedy in the On-Post ROD using an ESD which was approved by EPA on March 31, 2006 (TTECI 2006a). Follow-up is discussed in Section 9.7.

8.8 Off-Post Groundwater Intercept and Treatment System Performance Objectives Clarification

As noted in the assessment presented in 7.2.2.1, the OGITS is designed as and has been operated as a mass removal system. However, the use of containment terminology in descriptions of the system in several documents trigger comments regarding system performance and made it apparent that a clarification of system objectives was necessary The need to clarify the mass removal objective has not affected remedy protectiveness as the system has been operated as designed. Follow-up is provided in Section 9.8.

8.9 Northern Pathway System Modification

The property on which the NPS component of the OGITS is located was acquired by Amber Homes, Inc. whose plans for the property included the development of a large retail center and residential areas that entail construction at the NPS location. The modifications to the OGITS affect the NPS extraction system and the associated recharge wells used for reinjection of treated groundwater, as described in the Amber Homes Conceptual Design Document. The new NPS extraction wells will be operated concurrently with the original NPS extraction wells until the latter meet the shut-off criteria.

The system modification for the NPS was designed to meet or exceed the contaminant removal efficiencies of the original system. Also, the original system will continue to operate until shut-off criteria are met. The modification is therefore expected to have a positive impact on system effectiveness and maintain protectiveness. The construction of the NPS modification did not begin until November 2005 and had no impact on remedy protectiveness. Evaluation of the system will be included in the next FYRR because it was installed during the current FYR period. No additional follow-up action is required beyond the follow-up identified for the OGITS.

8.10 North Plants Fuel Release

Fuel contamination present as LNAPL was discovered in North Plants wells during the FYR period. As of the end of the FYR period, the need to perform additional characterization and/or remediation of the fuel contamination was being evaluated. Follow-up is provided in Section 9.10.

8.11 Changes in Monitoring Networks

Because of large-scale development and construction activities in the Off-Post OU, some Army monitoring wells have been destroyed and could not be re-drilled in the same locations. These unexpected changes to the off-post monitoring networks along with the significant reductions in the extent of off-post contamination have resulted in a need to review and potentially revise the off-post Exceedance Monitoring Network that was last updated in 2003. Follow-up is provided in Section 9.11.

8.12 Operational Assessment Report Schedule

The RS/Schedule for the Off-Post Operable Unit states that the OARs will be "published in the year following the reporting period" (HLA 1996a). The OARs were not developed within the RS/ S time requirement and concerns were raised by the Regulatory Agencies that delays in issuing the OARs prevent timely review and evaluation of remedy effectiveness. The OAR delays may affect the ability to conduct timely reviews, but the delays did not affect remedy protectiveness as the information presented in the OARs is evaluated on a continuous basis by system operators and provided to the Regulatory Agencies in monthly status meetings. Follow-up is provided in Section 9.12.

8.13 State Engineer's Office Well Notification Program (Off-Post Institutional Controls)

The primary mechanism for implementing the institutional controls is a well notification program developed in conjunction with the SEO and the Army. The Army prepares updates to a notification map and provides the map to the SEO for its use in notifying well permit applicants of their proximity to RMA groundwater contamination. After evaluation, TCHD has concluded that the SEO is not including the agreed upon notification on all well permits issued in the notification area and copies of the permits are not routinely being transmitted to all parties. The inconsistency in notification has not resulted in the use of contaminated drinking water wells in the notification area.

While the Army has provided the SEO with all the necessary information to implement the off-post well notification program, the SEO has not been following the agreed-upon notification process. This issue needs to be addressed to ensure that this institutional control continues the *"(p)revention of the use of the groundwater underlying areas of the Off-Post OU exceeding groundwater containment system remediation goals."* The well permit notification program is not consistently operating as intended as described in Sections 4.2.1.3, 5.2.2 and 7.2.2.3. Follow-up is provided in Section 9.13.

8.14 Other Unresolved Concerns

No other unresolved concerns from CDPHE, TCHD, the SAB, Restoration Advisory Board or other interested parties were identified.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

This section presents recommendation on how the issues identified in Section 8 will be addressed. A summary is provided in Table 9.0-1.

9.1 Basin F Wastepile

The On-Post ROD requires the Basin F Wastepile to be excavated and placed in an on-site triple-lined landfill, which began in the spring of 2006. Placement of all Basin F Wastepile material is currently scheduled to be completed by October 2008. There is no evidence that the secondary sump system of Cell #2 is leaking, but soils beneath the secondary sump system of Cell #2 will be monitored for staining during the Basin F Wastepile Excavation Project and reported in the next CCR.

9.2 Monitoring Well Maintenance and Security

The Army will ensure that the well maintenance and security issues are corrected in accordance with Army policies and procedures in the next FYR period. Inspections of off-post and on-post monitoring wells will be conducted and reported in accordance with the revised LTMP.

9.3 Extraction Well and Extraction System Shut-Off Criteria

Even though the Army concludes that this issue has not affected remedy protectiveness, more detailed and objective extraction well and system shut-off criteria will be proposed as part of the revisions to the LTMP. Different shut-off criteria will be considered for the systems based on whether they are containment or mass removal systems and whether they are boundary or internal systems.

9.4 Establishing Site-Specific PQLs

The Army recommends that the approach for establishing site-specific PQLs be revised and that a procedure for site-specific PQLs be developed. As of October 26, 2006, agreement has been reached with the Regulatory Agencies that PQL studies will be conducted in accordance with 40

CFR 136 Appendix B and soon-to-be published Colorado State PQL Guidance for compounds for which MRLs exceed CSRGs as outlined in decision document DD-RMAPQL-11. The site-specific PQLs determined from these studies will be implemented at RMA.

9.5 Bedrock Ridge Plume Capture

Based on monitoring and pumping tests in the Bedrock Ridge area, the Army recommended the addition of an extraction well to the Bedrock Ridge Intercept system to capture the flow of contaminated groundwater previously not captured by the system. The additional extraction well was installed in FY 2005. Remedy performance will be monitored and assessed by the RMA Water Team during the next FYR period.

9.6 Shell Disposal Trenches Dewatering

The Army recommends that the dewatering goal of achieving water levels below the bottom of the trenches be evaluated after both the RCRA-equivalent cover and adjacent soil covers have been installed at the Shell Disposal Trenches. This will allow meaningful assessment of the reduction of infiltration and lowering of groundwater levels in the Shell Trenches slurry wall enclosure caused by the cover systems. Water level monitoring will be performed and documented.

9.7 South Lakes Plume Management

The 2004 South Lakes Groundwater Monitoring Report concluded that there was no migration of contaminants into the South Lakes at levels exceeding CBSGs, and consequently, the goal of preventing the migration of contaminants into the South Lakes at levels exceeding the CBSGs has been met. As a result, the parties agreed that it was appropriate to remove the lake level maintenance requirement pertaining to plume management from the selected remedy in the On-Post ROD using an ESD. The ESD was approved on March 31, 2006 (TTECI 2006a).

As a separate part of the remedy, the Institutional Control Plan has established lake level performance criteria for the future, but only for the HHE soil and aquatic ecosystems ROD requirements of maintaining a healthy aquatic ecosystem and preventing human exposure to potentially contaminated sediments, respectively.

9.8 Off-Post Groundwater Intercept and Treatment System Performance Objectives Clarification

This FYRR clarifies that the OGITS has been and will continue to be operated as a mass removal system in accordance with the design and ROD documentation. The revised LTMP will provide specific performance criteria for evaluation of system mass removal effectiveness to facilitate future system evaluation presented in the OARs and FYRs. The Army believes that the need to clarify the overall remedial objectives of the system has not affected the system operation or protectiveness of the remedy during the FYR period.

9.9 Northern Pathway System Modification

The Army proceeded with the modifications to the NPS part of the OGITS in 2005. It is anticipated that the modifications will increase the mass removal effectiveness of the system and expedite the cleanup of the Off-Post OU. The performance of the modified NPS will be monitored during the next FYR period.

9.10 North Plants Fuel Release

Fuel remains as LNAPL in the North Plants vicinity. The LNAPL will be evaluated in accordance with applicable requirements during the next FYR period.

9.11 Changes in Monitoring Networks

A revised LTMP will be issued in 2007. All monitoring categories and containment and treatment systems identified in the 1999 LTMP and the Well Retention and Closure Program will be evaluated in the revised LTMP with regard to the following:

- Groundwater well networks
- Surface water monitoring network
- Analytes
- Monitoring frequencies
- Statistical method applications
- The system objectives and monitoring criteria will be addressed for all on-post and off-post containment and treatment systems. Modifications to the existing well networks will be based on established performance criteria. The conformance monitoring network will be re-evaluated to address the individual and system performance criteria.

9.12 Operational Assessment Report Schedule

Even though the Army has concluded that this issue has not affected remedy protectiveness, the Army will ensure that the OAR schedule provided in the RS/S be adhered to, starting with the 2005 OAR. The 2005 OAR was issued in a timely fashion in September of 2006..

9.13 State Engineer's Office Well Notification Program (Off-Post Institutional Controls)

Based on TCHD findings that the SEO deviated from the agreed upon notification process for well permits issued in the notification area, the following revised process is recommended:

- TCHD has agreed to review well application and permit data in the notification area quarterly under its current MOA with the Army.

Under this new recommended procedure the following will occur:

- Four times per year (once per quarter), TCHD will make a formal request to the SEO office for copies of well permits issued in the notification area.
- TCHD will review each permit to determine if the appropriate notification has been placed on the well permit and evaluate if the well user is or may in the future be extracting and using groundwater that exceeds CSRGs. If notifications are not being placed on well permits issued in the notification area, TCHD in conjunction with the Army will work with the SEO to improve the notification process.
- TCHD will notify the RVO, EPA, and CDPHE if a well permit is issued near an existing plume. If so the well will be included in the next round of sampling, and Army will provide notification to the EPA, CDPHE and TCHD if the sample result exceeds CSRGs.

- When warranted, TCHD will make individual contact with the permit recipient to provide a detailed explanation of the nature and extent of groundwater contamination in the off-post area.

10.0 PROTECTIVENESS STATEMENT

The protection of human health and the environment of the remedial actions in both the On-Post and Off-Post OUs is discussed below. All controls are in place to adequately minimize risks. Because the remedial actions at both the On-Post and Off-Post OUs are expected to be protective of human health and the environment upon completion, the remedy for the entire site is expected to be protective of both human health and the environment.

10.1 On-Post Operable Unit

The Army concludes that the remedy at the On-Post OU is expected to be protective upon completion or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. All immediate threats have been adequately addressed in the form of IRAs and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the On-Post ROD, as appropriate. The HWL, ELF and Basin A, which are central to the effective implementation of the remedy, have been expeditiously constructed and are operational. All other implementation projects are on schedule and in compliance with all elements of the On-Post ROD. Air, water, and biota monitoring programs are comprehensive in their design and effective in their implementation. Contaminant migration is being adequately controlled. Risks to human health and the environment are also being controlled by a comprehensive worker protection and access control program, institutional controls, and the past implementation of IRAs.

10.2 Off-Post Operable Unit

The Army concludes that the remedy at the On-Post OU is expected to be protective upon completion or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. All immediate threats have been adequately addressed in the form of IRAs and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the Off-Post ROD, as appropriate. Administrative controls to protect the public have been effective in their implementation. Groundwater contamination is being treated to Off-Post ROD remediation goals both at the RMA boundary as well as at the OGITS.

11.0 NEXT FIVE-YEAR REVIEW

The FYR for RMA should be conducted in 2010 covering the period April 1, 2005 through March 31, 2010.

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2003e (June 12) *Refinement of Remediation Areas for Surficial Soil and Reduction of Residual Biota Risk.*

2003f (Feb.) *Lake Mary Fact Sheet.*

2002a (Apr.) *North Boundary Containment/Treatment System Operational Assessment Report, FY00* Final Report.

2002b (June) *Offpost Groundwater Intercept Treatment System Operational Assessment Report, FY00* Final Report.

2002c (Sept.) *Rocky Mountain Arsenal Northwest Boundary Containment/Treatment System Operational Assessment Report,* FY01, Final Report.

2002d (July) *Partial Deletion Justification Addendum Western Tier Parcel*

2001a (Dec.) *Northwest Boundary Containment/Treatment System Operational Assessment Report, FY00* Final Report.

2001b (July 31) *Letter to EPA re: Draft Final Explanation of Significant Difference (ESD) for Endrin Containment System Remediation Goal in the On- and Off-Post Record of Decision for the Rocky Mountain Arsenal Federal Facility Site.*

2000a (Oct. 25) *Final Five-Year Review Report for Rocky Mountain Arsenal, Commerce City Adams County, Colorado.*

2000b (Mar.) *Basin A Operations Plan.* Rev C.1. pg 52, 4.3.2.3.

1997a (Aug. 13) *Memorandum of Agreement Between Tri-County Health Department and Program Manager for Rocky Mountain Arsenal.*

1997b (May) *Design Refinement of Excavation Boundaries for Surficial Soil and Reduction of Residual Biota Risk, Rocky Mountain Arsenal.*

1995 (Oct. 16) *On-Post Operable Unit Detailed Analysis of Alternatives Dispute Resolution Agreement.*

1981 (Aug.) *Conceptual Design of the Northwest Boundary Containment System.*

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1992 (Oct.) *Rocky Mountain Arsenal National Wildlife Refuge Act of 1992.*

RMA Council (RMA Council)

2004a (Aug. 24) *Resolution on the Path Forward for Site ESA-4.*

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RMA (Rocky Mountain Arsenal)

1981 (Aug.) *Conceptual Design of the Northwest Boundary Containment System.*

RVO (Remediation Venture Office)

2006a (Mar.) *Miscellaneous Northern Tier Soil Remediation Project Construction Completion Report Addendum 1.* Revision 1.

2006b (June) *Miscellaneous Southern Tier Soil Remediation Project Construction Completion Report Addendum 1.* Revision 0.

2006c (June 30) *Letter transmitting the Notification Map based on the 2004 Off-Post Exceedance Map to the Colorado Department of Natural Resources State Engineer's Office and the Regulatory Agencies.*

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2004d (Feb.) *Section 26 Human Health Exceedance and Biota Soils Removal Project Construction Completion Report Addendum 1.* Revision 0.

2004e (Feb.) *Existing (Sanitary) Landfill Remediation Section 1 ,Construction Completion Report Addendum 1.* Revision 0

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2003b (Dec. 16) *Letter transmitting the 2002 Off-Post Exceedance Map to the Colorado Department of Natural Resources State Engineer's Office.*

2003c (Mar. 25) *Letter to EPA confirming finalization of the Documentation of Non-Significant or Minor Off-post ROD Change at RMA of the CFS Well Evaluation Criteria.*

2003d (Mar. 25) *Letter to EPA confirming finalization of the Documentation of Non-Significant or Minor Off-post ROD Change at RMA of the CSRG for the NWBCS.*

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2002b (Mar. 6) *Resolution Agreement South Plants Central Processing Area Soil Remediation Project.*

2002c (Mar. 21) *Letter to EPA, Draft Final Fact Sheet, Documentation of Non- Significant or Minor Off-post ROD Change at RMA of the CFS Well Evaluation Criteria.*

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2001b (Sept. 25) *VOC policy letter to the Regulatory Agencies.*

1998 (Sept. 30) *Corrective Action Management Unit Soil Remediation Construction Completion Report.*

1997a (Nov.) *Complex Trenches and Shell Section 36 Trenches Groundwater Barrier Project, 100 Percent Design Package.* Revision 1.

1997b (Sept.) *Biota Barriers for Cap and Cover Systems* Basin A.

1997c (Sept. 29) *Basin A Consolidation and Remediation Project final Design Package.* Revision 0.

SCA (Sanford Cohen and Associates)
1998 (Dec. 30) *Final Report, Geophysical Screening Activities and Results.*

Shell Oil (Shell Oil Company)
1990 (Mar.) *Development of Chloride and Sulfate Remediation Goals for the North Boundary Containment System at the Rocky Mountain Arsenal.*

TCHD (Tri-County Health Department)
2005 (Oct. 3) *Memo to RMA File, Re: State Engineers Office Findings.*

TTECI (Tetra Tech EC Inc.)
2006a (Mar. 31) *Explanation of Significant Differences for Groundwater Remediation and Revegetation Requirements.* Revision 0.

2006b (Mar. 24) *Site-Wide Remediation Projects Remediation Waste Management Plan.* Revision 4.

2006c (Feb. 21) *Site-Wide Air Quality Monitoring Program Plan.* Revision 2.

2006d (May 5) *Explanation of Significant Differences for the Shell Disposal Trenches Remediation Project, Rocky Mountain Arsenal Federal Facility Site,* Revision 0..

2006e (Mar. 30) *Data Summary Report for Sand Creek Lateral Soils Remediation Project.* Revision 0.

2006f (Feb. 27) *Miscellaneous RMA Structure Demolition and Removal Project – Phase 2 Design Change Notice MSD2-013.*

2006g (Mar. 9) *Miscellaneous RMA Structure Demolition and Removal Project – Phase 2 Construction Completion Report.* Revision 1.

2006h (Feb. 2) *Borrow Areas Management Data Summary Report for Residual Ecological Risk Sites.* Revision 1.

2006i (Mar. 13) *Residual Ecological Risk Soil Remediation – Part 1 Construction Completion Report.* Revision 0.

2006j (May 1) *Vegetation Management Plan.*

2006k (July) *Hazardous Waste Landfill, Landfill Wastewater Treatment System and Enhanced Hazardous Waste Landfill, Final Annual Groundwater Monitoring Report for July 2004-June 2005.* Revision 0.

2005a (Oct. 20) *Amendment to the Record of Decision for the On-Post Operable Unit, Rocky Mountain Arsenal Federal Facility Site, Section 36 Lime Basins Remediation, Basin F Principal Threat Soil Remediation.* Revision 0.

2005b (May 9) *Explanation of Significant Differences for Existing (Sanitary) Landfills Soil Remediation Project.* Revision 0.

2005c (July 28) *Section 30 Existing (Sanitary) Landfills Remediation Project Construction Completion Report.* Revision 1.

2005d (Nov. 1) *Basin F/Basin F Exterior Remediation Project- Part 1 Construction Completion Report,* Final, Revision 0.

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TTEMI (Tetra Tech EM, Inc.)

2003 *Hydrogen Release compound Barrier Application at the North of Basin F Site, Rocky Mountain Arsenal, Draft.*

TTFWI (Tetra Tech FW, Inc.)

2005a (Apr. 12) *Summary of Remedial Alternatives for Section 36 Lime Basins and Former Basin F Principal Threat Soil Remediation Projects. Revision 0.*

2005b (April) *Hazardous Waste Landfill, Landfill Wastewater Treatment System and Enhanced Hazardous Waste Landfill, Final Annual Groundwater Monitoring Report for July 2003-June 2004.* Revision 0.

2004a (Apr. 9) *Section 36 Existing (Sanitary) Landfills Remediation Project Construction Completion Report.* Revision 0.

2004b (June 9) *Explanation of Significant Differences for Burial Trenches Soil Remediation Project.* Revision 0.

2004c (Sep. 27) *Burial Trenches Soil Remediation Project Construction Completion Report Part II.* Revision 0.

2004d (Mar. 26) *Munitions (Testing) Soil Remediation Project Construction Completion Report, Part I.* Revision 5.

2004e (June 8) *Hex Pit Soil Remediation [Redesign] Construction Completion Report.* Revision 0.

2004f (May 13) *Secondary Basins Soil Remediation Project Construction Completion Report.* Revision 1.

2004g (June 29) *North Plant Soil Remediation Project Petroleum-Impacted/Stained Soils, Final Data Summary Report.* Revision 0.

2004h (Dec. 3) *North Plants Soil Remediation Project Petroleum Release Evaluation Report.* Revision 0.

2004i (Sept. 24) *Explanation of Significant Differences for North Plants Structure Demolition and Removal Project.* Revision 0.

2004j (Sep. 28) *North Plant Structure Demolition and Removal Remediation Project and Destruction of Equipment in the GB Production and Fill Facilities Project.* Revision 1.

2004k (Oct. 11) *Final Residual Risk Soil Concentration Verification Sampling and Analysis Plan Soil Tilling Demonstration Study.* Revision 1.

2004l (Nov.) *Well Networks Update For Retention and Closure, Water Year 2004.*

USACE (U.S. Army Corps of Engineers)

1985 (Dec.) *North Boundary Containment/Treatment System Performance Report.*

USFWS (United States Fish and Wildlife Service)

2006a (June 29) *Letter to EPA, from USFWS as resource trustee, certifying completion or transfer of remedy sites to the USFWS in accordance with the revegetation ESD.*

2006b (Oct. 5) *Rocky Mountain Arsenal National Wildlife Refuge, Commerce City, Colorado Annual Narrative Report Fiscal Year 2004.*

2006c (Oct. 5) *Rocky Mountain Arsenal National Wildlife Refuge, Commerce City, Colorado Annual Narrative Report Fiscal Year 2003.*

2006d (Oct. 5) *Rocky Mountain Arsenal National Wildlife Refuge, Commerce City, Colorado Annual Narrative Report January 1, 2001 – September 30, 2002.*

2004 (Oct.) *Rocky Mountain Arsenal National Wildlife Refuge Public Use Plan.*

2002a (Aug. 12) *Evaluation of Unbackfilled Human Health Exceedance Excavation Areas for Potential Biota Risks.*

2002b (Nov. 25) *Rocky Mountain Arsenal National Wildlife Refuge, Commerce City, Colorado, including Two Ponds National Wildlife Refuge Annual Narrative Report Calendar Year 2000.*

2000 (Feb.) *Rocky Mountain Arsenal National Wildlife Refuge Fiscal Year 1999 Annual Progress Report.*

1999a (Aug.) *Rocky Mountain Arsenal National Wildlife Refuge Habitat Restoration Plan.*

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1998 (Feb.) *Rocky Mountain Arsenal National Wildlife Refuge Fiscal Year 1997 Annual Progress Report.*

1997 (Jan.) *Rocky Mountain Arsenal National Wildlife Refuge Fiscal Year 1996 Annual Progress Report.*

1996a (Mar.) *Rocky Mountain Arsenal National Wildlife Refuge Comprehensive Management Plan.*

1996b (Oct.) *Rocky Mountain Arsenal National Wildlife Refuge Fiscal Year 1995 Annual Progress Report.*

USGS (U.S. Geological Survey Water Resources Division Colorado District RMA Project Office)

2005a (May) *Long-Term Monitoring Program Rocky Mountain Arsenal Annual Data Summary 2004 Water Year.*

2005b *U.S. Geological Survey Scientific Investigations Report 2005-5214, Surface Water-quality and Water-quantity Data from Selected Urban Runoff-monitoring Sites at the Rocky Mountain Arsenal, Water Years 1988-2004.*

2004a (Mar.) *Final South Lakes Groundwater Monitoring Report, June 1, 2001 – May 31, 2003.*

2004b (May) *Long-Term Monitoring Program Rocky Mountain Arsenal Annual Data Summary 2003 Water Year.*

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2002 (Apr.) *Long-Term Monitoring Program Rocky Mountain Arsenal Annual Data Summary 2001 Water Year.*

2001a (May) *Rocky Mountain Arsenal South Lakes Sampling and Analysis Plan for Groundwater.*

2001b (Apr.) *Long-Term Monitoring Program Rocky Mountain Arsenal Annual Data Summary 2000 Water Year.*

1998 (Apr.) *National Field Manual for the Collection of Water Quality Data,* Book 9.

Weston (Roy F. Weston, Inc.)

1992 (Dec.) *Final Decision Document for Element one of the CERCLA Hazardous Wastes Interim Response Action at the Rocky Mountain Arsenal.*

WGI (Washington Group International)

2006 (Mar. 2) *Explanation of Significant Differences for the Section 36 Bedrock Ridge Groundwater Plume Extraction System, Rocky Mountain Arsenal Federal Facility Site,* Revision 1.

2005 (Sept.) *Termination of Operation at the Groundwater Intercept and Treatment System North of Basin F Well, Final Construction Completion Report.*

2004 (Apr. 16) *Modification to the Basin A-Neck Recharge Trench System, Design Change Notice Number3*, Revision 2.

2003a (Dec. 18) *Modification to the Basin A-Neck Recharge Trench System, Design Change Notice Number 2.*

2003b (May) *Rocky Mountain Arsenal, Irondale Containment System, Shut-Down for the Irondale Extraction System, Final Construction Completion Report.* Revision 1.

2000 (Sept. 8) *Interior Building Chemical Related Activities for South Plants Construction Completion Report.* Revision 1.

Walker, D. Lewis (Deputy Assistant Secretary of the Army, Environment, Safety and Occupational Health)

1993 (Feb. 3) *Letter to Jack McGraw Acting Regional Administrator of EPA Region VII Regarding the Construction of Buildings with Basements at RMA.*

TABLES

Table 2.0-1 - Chronology of ROD-Related Events

Date	Event
1942	Establishment of RMA
Late 1950s	Off-Post groundwater contamination first suspected
1974	Army establishes the RMA Contamination Control Program.
Apr. 1975	Colorado Department of Health issues a Cease and Desist Cleanup and Monitoring Order to RMA in connection with the alleged pollution of ground and surface waters north of RMA.
1977	Army installs pilot groundwater containment system at the north boundary
1978-1984	Army and Shell install three boundary groundwater containment systems.
1984	Site proposed for addition to the National Priorities List (NPL)
1984	Army completes a Preliminary Assessment and Site Inspection that identifies 179 potentially contaminated sites.
1985	First Interim Response Action completed
Aug. 1987	Rocky Mountain Arsenal added to the NPL
Feb. 1989	Federal Facility Agreement signed
Jan. 1992	Remedial Investigation completed
Dec. 1992	Development and Screening of Alternatives completed
Oct. 1995	Detailed Analysis of Alternatives completed
Dec. 1995	Record of Decision signed for Off-Post Operable Unit
Jun. 1996	Record of Decision signed for On-Post Operable Unit
May 1999	Technical Justification Report for Volume Modification of Toxic Storage Yards Soil Remediation Project
Oct. 2000	RMA First Five-Year Review Report Issued
Nov. 2000	ESD issued on Chemical Sewer Remediation – Sect. 35 & Section 26
Nov. 2000	ESD on South Plants Balance of Areas & Central Processing Area Soil Remediation Project
Nov. 2001	ESD on Change in Endrin Standard for Treatment Systems (NBCS, NWBCS, Basin A Neck, & OGITS)
Feb. 2002	ESD on Secondary Basins Soil Remediation Project
Jan. 2003	Deleted approximately 940 acres on the west side of RMA from the NPL
Apr. 2003	On-Post ROD Amendment for Hex Pit Remediation
Apr. 2003	ESD on Section 36 Balance of Areas Soil Remediation Project
Dec. 2003	Removed Chemical Weapons Convention Treaty Monument
Jan. 2004	Deleted approximately 5,053 acres mostly on the south & east sides of RMA from the NPL
Apr. 2004	RMA National Wildlife Refuge officially established
Jul. 2004	ESD on Burial Trenches Soil Remediation Project
Sep. 2004	ESD on North Plants Structure Demolition & Removal Project
May 2005	ESD on Existing (Sanitary) Landfills Soil Remediation Project
Oct. 2005	On-Post ROD Amendment for the Section 36 Lime Basins and Basin F Principal Treat Soil Projects
May 2006	ESD on Section 36 Bedrock Ridge Groundwater Plume Extraction System
Mar. 2006	ESD on Groundwater Remediation and Revegetation Requirements
June 2006	ESD on Shell Disposal Trenches Project
July 2006	Deleted approximately 7,396 acres

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
On-Post OU				
1	CAMU/Basin A Well Abandonment	Completed	N/A	Discussed in 2000 FYR
2	CAMU Soil Remediation	Completed	N/A	Discussed in 2000 FYR.
	CAMU Soils Remediation Completion and Support	Completed	N/A	CCR September 29, 2000, discussed at 4.3.3.1 and 7.3.1
3	Construction of Hazardous Waste Landfill Wastewater Treatment Unit	Completed	N/A	CCR September 27, 2000, discussed at 4.3.3.2 and 7.3.2.
4	Construct Hazardous Waste Landfill Cell 1	Completed	N/A	CCR September 27, 2000, discussed at 4.3.3.2 and 7.3.2.
5	Section 26 Human Health Exceedance and Biota Exceedance Soils Removal	Completed	N/A	CCR October 17, 2000, discussed at 4.3.3.3 and 7.3.3. Addendum March 30, 2006 additional CSV.
6	Construct Hazardous Waste Landfill Cell 2	Completed	N/A	CCR April, 18 2001, discussed at 4.3.3.4 and 7.3.4.
7	Operation of Hazardous Waste Landfill Cells 1 & 2	Operating	N/A	CCR Forecast TBD, discussed at 4.3.2.1 and 7.2.3.1.
8	Closure (cover construction) of Hazardous Waste Landfill Cells 1 & 2	Not yet begun	N/A	CCR Forecast late 2008
9	Enhanced Hazardous Waste Landfill Ion Exchange to LWTU	Not yet begun	N/A	CCR Forecast TBD
10	Operation of Hazardous Waste Landfill Wastewater Treatment Unit	Operating	N/A	Discussed at 4.3.2.2 and 7.2.3.2.
11	Construct Enhanced Hazardous Waste Landfill	Under Construction	N/A	CCR Forecast early 2007, discussed at 4.3.1.1 and 7.1.1.

- Not Yet Begun - Under Construction - Operating - Completed - Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
12	Operation of Enhanced Hazardous Waste Landfill	Not yet begun	04/06	CCR Forecast mid- 2008
13	Closure of Enhanced Hazardous Waste Landfill Cover	Not yet begun	TBD	CCR Forecast early 2011
14	Operation of Basin A Consolidation and Remediation Area	Operating	N/A	CCR Forecast mid- 2007, discussed at 4.3.2.3 and 7.2.3.3.
15	Closure of Basin A Consolidation and Remediation Area Cover Construction Phase 1	Not yet begun	07/07	CCR Forecast early 2010
	Closure of Basin A Consolidation and Remediation Area Notch Operations/Cover Placement	Not yet begun	TBD	CCR Forecast early 2012
16	Sanitary and Chemical Sewer Manhole Plugging Phase I	Completed	N/A	Discussed in 2000 FYR
17	Shell Disposal Trenches Slurry Walls (construction)	Completed	N/A	CCR June 8, 2001, discussed at 4.3.3.5 and 7.3.5.
	Shell Disposal Trenches Slurry Walls (dewatering)	Operating	NA	CCR Forecast mid- 2001, discussed at 4.1.2.1 and 7.2.1.1.
	Complex (Army) Disposal Trenches Slurry Walls (construction)	Completed	N/A	CCR July 3, 2001, discussed at 4.3.3.6 and 7.3.6. Addendum September 30, 2002 System Operational and Functional.
	Complex (Army) Disposal Trenches Slurry Walls (dewatering)	Operating	N/A	CCR Forecast mid- 2011, discussed at 4.1.2.2 and 7.2.1.2.
18	Post-ROD Removal Actions for Structures – Administrative Areas Asbestos Remediation Projects	Completed	N/A	CCR September 29, 2003, discussed at 4.4.2.1 and 7.3.7 with the balance of asbestos addressed in remaining remedy projects.
	Post-ROD Removal Actions for Structures – Exterior Piping Chemical-Related Activities	Completed	N/A	Discussed in 2000 FYR

- Not Yet Begun - Under Construction - Operating - Completed - Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
	Post-ROD Removal Actions for Structures - Interior Building Chemical Related Activities for South Plants	Completed	N/A	CCR September 30, 2000, discussed at 4.4.2.1 and 7.3.7.
19	Toxic Storage Yards Soil Remediation	Completed	N/A	CCR June 20, 2000, discussed at 4.3.3.7 and 7.3.8.
20	Existing (Sanitary) Landfills Remediation Section 1	Completed	N/A	CCR discussed in 2000 FYR. Addendum March 30, 2006, additional excavation of unbackfilled HHE area, discussed at 4.3.3.8. and 7.3.9.
21	Existing (Sanitary) Landfills Remediation Section 4	Completed	N/A	CCR May 25, 2000, discussed at 4.3.3.9 and 7.3.10.
22	Existing (Sanitary) Landfills Remediation Section 36	Completed	N/A	CCR July 15, 2004; discussed at 4.3.3.10 and 7.3.11.
	Existing (Sanitary) Landfills Remediation Section 30	Under Construction	N/A	CCR August 16, 2005, discussed at 4.3.1.2 and 7.1.2.
23	Lake Sediments Remediation	Completed	N/A	CCR April 20, 2000, discussed at 4.3.3.11 and 7.3.12.
24	Burial Trenches Soil Remediation Part I	Completed	N/A	CCR September 25, 2002, discussed at 4.3.3.12 and 7.3.13.
	Burial Trenches Soil Remediation Part II	Completed	N/A	CCR September 30, 2004, discussed at 4.3.3.12 and 7.3.13.
25	Munitions (Testing) Soil Remediation Part I	Completed	N/A	CCR July 15, 2004, discussed at 4.3.3.13 and 7.3.14.
	Munitions (Testing) Soil Remediation Part II	Under Construction	N/A	CCR Forecast early 2007, discussed at 4.3.1.3 and 7.1.3.
26	Miscellaneous Northern Tier Soil Remediation	Completed	N/A	CCR April 20, 2000, discussed at 4.3.3.14 and 7.3.15. Addendum March 30, 2006, additional CSV.
27	Miscellaneous Southern Tier Soil Remediation	Completed	N/A	CCR July 14, 2000, discussed at 4.3.3.15 and 7.3.16.

- Not Yet Begun
- Under Construction
- Operating
- Completed
- Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
				Addendum March 30, 2006, additional deep acute soil.
	Miscellaneous Southern Tier Soil Remediation, Sand Creek Lateral	Not yet begun	TBD	CCR Forecast mid- 2007
28	Section 36 Bedrock Ridge Groundwater Barrier Plume Extraction System	Under Construction	N/A	CCR Forecast mid- 2007, discussed at 4.1.1.1 and 7.1.4.
29	South Plants Structures Demolition and Removal Phase 1	Completed	N/A	CCR September 29, 2000, discussed at 4.4.2.2 and 7.3.17.
	South Plants Structures Demolition and Removal Phase 2	Completed	N/A	CCR July 2, 2002, discussed at 4.4.2.2 and 7.3.17.
30	Miscellaneous RMA Structures Demolition and Removal Phase 1	Completed	N/A	CCR September 30, 2002, discussed at 4.4.2.3 and 7.3.18.
	Miscellaneous RMA Structures Demolition and Removal Phase II	Under Construction	N/A	CCR March 30, 2006, discussed at 4.4.1.1 and 7.1.5.
	Miscellaneous RMA Structures Demolition and Removal Phase III	Not yet begun	01/10	CCR Forecast early 2011
31	Buried M-1 Pits Soil Remediation	Completed	N/A	CCR July 18, 2002, discussed at 4.3.3.16 and 7.3.19.
32	Hex Pit Soil Remediation	Completed	N/A	CCR July 21, 2004, discussed at 4.3.3.17 and 7.3.20.
33	South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 1	Completed	N/A	CCR September 24, 2002, discussed at 4.3.3.18 and 7.3.21.
34	South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2 Part 1 and 2	Under Construction	N/A	CCR Forecast early 2007, discussed at 4.3.1.4 and 7.1.6.

- Not Yet Begun   - Under Construction   - Operating   - Completed   - Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
	South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2, Part 3 Cover Construction	Not yet begun	3/07	CCR Forecast early 2011.
34	South Plants Balance of Areas and Central Processing Area Cover Operating Properly and Successfully (OPS) Determination	Not yet begun	TBD	OPS Determination Summer 2015.
35	Sanitary Sewer Manhole Plugging Project Phase II	Not yet begun	03/10	CCR Forecast early 2010
36	Section 36 Balance of Areas Soil Remediation	Under Construction	N/A	CCR Forecast early 2007, discussed at 4.3.1.5 and 7.1.7.
37	Secondary Basins Soil Remediation, Phase I and II	Completed	N/A	CCR July 15, 2004, discussed at 4.3.3.19 and 7.3.22.
38	Complex (Army) Disposal Trenches Remediation Subgrade Construction	Not yet begun	09/05	CCR Forecast early 2007
	Complex (Army) Disposal Trenches Remediation Cover Part 1	Not yet begun	12/06	CCR Forecast early 2010
	Complex (Army) Disposal Trenches Remediation Cover Part 2, Operating Properly and Successfully (OPS) Determination	Not yet begun	TBD	OPS Forecast mid- 2014
39	Shell Disposal Trenches Remediation Cover Part 1	Not yet begun	04/05	CCR Forecast early 2008
	Shell Disposal Trenches Remediation Cover Part 2	Not yet begun	06/06	CCR Forecast early 2009
	Shell Disposal Trenches Remediation Cover Operating Properly and Successfully (OPS) Determination	Not yet begun	TBD	OPS Forecast mid- 2012

- Not Yet Begun
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Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
40	North Plants Soil Remediation Free Product Removal	Not yet begun	TBD	CCR Forecast TBD
	North Plants Soil Remediation Site Grading	Not yet begun	TBD	CCR Forecast TBD
41	Section 35 Soil Remediation	Completed	N/A	CCR July 15, 2004, discussed at 4.3.3.20 and 7.3.23.
	Section 35 Soil Remediation, Sand Creek Lateral	Not yet begun	TBD5	CCR Forecast early 2007
42	North Plants Structure Demolition and Removal	Completed	N/A	CCR September 30, 2004, discussed at 4.4.2.4 and 7.3.24.
43	Basin F Wastepile Remediation	Under Construction	N/A	CCR Forecast early 2008, discussed at 4.3.1.6 and 7.1.8.
44	Former Basin F Principal Threat Soil Remediation (formerly known as Former Basin F Solidification)	Not yet begun	02/07	CCR Forecast late 2008
45	Basin F and Basin F Exterior Remediation Phase I	Under Construction	N/A	CCR October 12, 2006, discussed at 4.3.1.7 and 7.1.9.
46	Basin F and Basin F Exterior Remediation Phase II Cover	Not yet begun	03/09	CCR Forecast early 2011
	Basin F and Basin F Exterior Remediation Phase II Cover, Operating Properly and Successfully (OPS) Determination	Not yet begun	TBD	OPS Forecast mid- 2016
47	Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall	Not yet begun	TBD	CCR Forecast mid- 2008
	Section 36 Lime Basins Soil Remediation Cover Part 1	Not yet begun	TBD	CCR Forecast early 2012
	Section 36 Lime Basins Soil Remediation Cover Part 2, Operating Properly and Successfully (OPS) Determination	Not yet begun	TBD	OPS Forecast mid- 2016

- Not Yet Begun - Under Construction - Operating - Completed - Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
47a	Borrow Areas Operations	Operating	N/A	Discussed at 4.3.2.4 and 7.2.3.4.
48	Site-Wide Biota Monitoring	Operating	N/A	Discussed at 4.5.1.1 and 7.2.3.5.
49	Site-Wide Air Monitoring	Operating	N/A	Discussed at 4.5.1.2 and 7.2.3.6.
50	Site-Wide Groundwater Monitoring	Operating	N/A	Discussed at 4.1.2.3 and 7.2.3.8.
51	UXO Management	Operating	N/A	Discussed at 4.5.1.3 and 7.2.3.9.
52	Medical Monitoring Program	Operating	N/A	Discussed at 4.5.1.4 and 7.2.3.10.
53	Western Tier Parcel (deletion)	Completed	N/A	Deletion occurred on January 21, 2003. Discussed at 4.5.2.1 and 7.3.25.
54	Trust Fund	Completed	N/A	Discussed at 4.5.2.2 and 7.3.26.
55	South Adams County Water Supply	Completed	N/A	Discussed in 2000 FYR
56	Henderson Distribution	Completed	N/A	Discussed in 2000 FYR
57	Confined Flow System Well Closures	Completed	N/A	CCR September 27, 2000, discussed at 4.1.3.1 and 7.3.27.
58	Irondale Containment System Main Wellfield Treatment Shutdown	Completed	N/A	CCR May 21, 2003, discussed at 4.1.3.2 and 7.3.28.
	Motor Pool Area Treatment System Operation	Operating	N/A	CCR Forecast mid- 2007, discussed at 4.1.2.4 and 7.2.1.3.
	Rail Classification Yard Treatment System Operation	Operating	N/A	CCR Forecast mid- 2012, discussed at 4.1.2.4 and 7.2.1.3.

- Not Yet Begun - Under Construction - Operating - Completed - Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
59	North of Basin F Groundwater Plume Remediation System	Operating	N/A	CCR Forecast late 2005, discussed at 4.1.2.6 and 7.2.3.11.
	Basin A Neck Containment System Operation	Operating	N/A	CCR Forecast TBD, discussed at 4.1.2.5 and 7.2.1.4.
60	Operation of CERCLA Wastewater Treatment Facility	Operating	N/A	MCR, is required at plant shutdown and demolition. CCR for demolition covered under Misc. Structures Phase III Forecast early 2011, discussed at 4.5.1.5 and 7.2.3.12.
	Operations/Treatment of South Tank Farm and Lime Basins Mass Removal System	Not yet begun	08/05	CCR Forecast TBD
61	Northwest Boundary Containment System Operation	Operating	N/A	CCR Forecast TBD, discussed at 4.1.2.7 and 7.2.1.5.
62	North Boundary Containment System Operation	Operating	N/A	CCR Forecast TBD, discussed at 4.1.2.8 and 7.2.1.6.
63	NDMA Monitoring and Assessment	Completed	N/A	Discussed in 2000 FYR
64	South Lakes Plume Management	Operating	N/A	ESD finalized March 31, 2006, discussed at 4.1.2.9 and 7..2.1.7.
65	Basin F Wastepile Operations and Management	Operating	N/A	Discussed at 4.3.2.5 and 7.2.3.13.
66	Off-Post Groundwater Intercept and Treatment System (IRA)	Transferred – see #94	N/A	N/A
67	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA) – North Boundary Containment System Improvements	Transferred – see #62	N/A	N/A
68	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA) -	Transferred – see #58	N/A	N/A

- Not Yet Begun; - Under Construction; - Operating; - Completed; - Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
	Irondale Containment System			
69	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA) - Northwest Boundary Containment System	Transferred – see #61	N/A	N/A
70	Groundwater Intercept and Treatment North of Basin F (IRA)	Transferred – see #59	N/A	N/A
71	Closure of Abandoned Wells at RMA (IRA)	Completed	N/A	Completed 10/89, discussed in 2000 FYR. For additional identified work see #95
72	Basin A Neck Containment System(IRA)	Transferred – see #59	N/A	N/A
73	Basin F Liquid, Sludge, and Soil Remediation (IRA) Element One, Basin F Wastepile	Transferred – see #63 and #40	N/A	N/A
74	Basin F Liquid, Sludge, and Soil Remediation (IRA) Element Two, Basin F Liquid	Completed	N/A	Completed 05/96, discussed in 2000 FYR.
75	Building 1727 Sump Liquid (IRA)	Completed	N/A	Completed 11/87, discussed in 2000 FYR.
76	Closure of the Hydrazine Facility (IRA)	Completed	N/A	Completed 07/92, discussed in 2000 FYR.
77	Fugitive Dust Control (IRA)	Completed	N/A	Completed 05/91, discussed in 2000 FYR.
78	Sanitary Sewers Remediation (IRA)	Completed	N/A	Completed 09/92, discussed in 2000 FYR.
79	Asbestos Remediation (IRA)	Transferred – see #18	N/A	N/A

- Not Yet Begun - Under Construction - Operating - Completed - Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
80	Remediation of Other Contamination Sources (IRA) - Motor Pool Area, Soil Vapor Extraction	Completed	N/A	Completed 10/93, discussed in 2000 FYR.
81	Remediation of Other Contamination Sources (IRA) - Motor Pool Area, Groundwater Remediation	Completed	N/A	Completed 10/93, discussed in 2000 FYR.
82	Remediation of Other Contamination Sources (IRA) - Rail Classification Yard	Transferred – see #58	N/A	N/A
83	Remediation of Other Contamination Sources (IRA) - Lime Settling Basins	Transferred – see #47	N/A	N/A
84	Remediation of Other Contamination Sources (IRA) - South Tank Farm Plume	Completed	N/A	Completed 10/93, discussed in 2000 FYR.
85	Remediation of Other Contamination Sources (IRA) - Army (Complex) Disposal Trenches	Transferred – see #17, #38, #39, and #50	N/A	N/A
86	Remediation of Other Contamination Sources (IRA) - Shell Section 36 Trenches	Transferred – see #17, #38, #39, and #50	N/A	N/A
87	Remediation of Other Contamination Sources (IRA) - M-1 Settling Basins	Transferred – see #31	N/A	N/A
88	Pretreatment of CERCLA Liquid Wastes (IRA) – Wastewater Treatment System	Transferred – see #60	N/A	N/A
89	Pretreatment of CERCLA Liquid Wastes (IRA) – Element	Transferred –	N/A	N/A

- Not Yet Begun - Under Construction - Operating - Completed - Completed and Documented in 2000 FYRR.

Table 2.0-2 - RMA Remedial Projects Status as of March 31, 2005

#	Project Name	Status	Forecast Start	Forecast or Date of Final CCR EPA Approval and 2005 FYRR cross reference
	One, Waste Management	see #30		
90	Pretreatment of CERCLA Liquid Wastes (IRA) –Element Two, Polychlorinated Biphenyls (PCBs)	Completed	N/A	Completed 05/96, discussed in 2000 FYR.
91	Pretreatment of CERCLA Liquid Wastes (IRA) – Element Three, Waste Storage	Transferred – see #30	N/A	N/A
92	Chemical Process-Related Activities (IRA)	Transferred – see #27, #29, and #42	N/A	N/A
93	Deep Disposal Well Closure (IRA)	Completed	N/A	Completed 09/85, discussed in 2000 FYR.
Off-Post OU				
94	Operation of Off-Post Groundwater Intercept and Treatment System	Operating	N/A	Discussed at 4.2.1.1 and 7.2.2.1.
95	Off-Post Well Abandonment	Completed	N/A	Discussed in 2000 FYR
96	Private Well Network	Operating	N/A	Discussed at 4.2.1.2, 6.4.1.6 and 7.2.2.2.
97	Off-Post Tillage Task	Completed	N/A	Discussed in 2000 FYR
98	Off-Post Institutional Controls	Operating	N/A	Discussed at 4.2.1.3 and 7.2.2.3.

- Not Yet Begun - Under Construction - Operating - Completed - Completed and Documented in 2000 FYRR.

Table 3.0-1 – Chemicals of Concern

On-Post OU Soil COCs[1]	Off-Post OU Soil COCs[2]	Off-Post OU Sediment COCs[3]	Off-Post OU Groundwater COCs[4]	Off-Post OU Surface Water COCs[5]
Aldrin	Aldrin	Aldrin	Aldrin	Arsenic
Arsenic	Chlordane	DBCP	Arsenic	Chlordane
Benzene	Dieldrin	Dieldrin	Atrazine	Chloride
Cadmium	Endrin	Endrin	Benzene	DCPD
Carbon Tetrachloride	DDE	DDE	Carbon tetrachloride	DDE
Chlordane	DDT	DDT	Chlordane	DDT
Chloroacetic Acid			Chloride	Dieldrin
Chlorobenzene			Chlorobenzene	DIMP
Chloroform			Chloroform	Fluoride
Chromium			CPMSO	Sulfate
DBCP			$CPMSO_2$	
DCPD			DBCP	
DDE			1,2-Dichloro-ethane	
DDT			DCPD	
1,2-Dichloro-ethane			DDE	
1,1-Dichloroethylene			DDT	
Dieldrin			Dichlorobenzene	
Endrin			DIMP	
HCCPD			Dieldrin	
Isodrin			Dithiane	
Lead			Endrin	
Mercury			Ethylbenzene	
Methylene Chloride			Fluoride	
1,1,2,2-Tetrachloroethane			HCCPD	
Tetrachloroethylene			Isodrin	
Toluene			Malathion	
Trichloroethene			Manganese	
			Oxathiane	
			Sulfate	
			Tetrachloroethylene	
			Toluene	
			Trichloroethene	
			Xylene	

[1] = From Table 6.1-1, On-Post ROD
[2] = From Table 6.4, Off-Post ROD
[3] = From Table 6.3, Off-Post ROD
[4] = From Table 6.1, Off-Post ROD
[5] = From Table 6.2, Off-Post ROD

CPMSO 4-Chlorophenylmethyl sulfoxide
$CPMSO_2$ 4-Chlorophenylmethyl sulfone
DBCP Dibromochloropropane
DCPD Dicyclopentadiene
DDE 2,2-bis(p-chlorophenyl)-1,1-dichloroethene
DDT 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane
DIMP Diisopropylmethyl phosphonate
HCCPD Hexachlorocyclopentadiene

Note: No risk assessment was conducted for on-post groundwater, in accordance with the FFA, which prohibits potable use of groundwater and surface water along with agricultural activities and consumption of fish and game. Risk assessments were conducted for soil and off-post groundwater for which COCs were identified. During the investigation leading up to the ROD, groundwater monitoring was conducted for the analyte lists identified through the Comprehensive Monitoring Program and Groundwater Monitoring Program. Modifications to these programs were made during the course of the investigation in response to requests from all parties. The CSRG lists that apply to effluents for the different on-post containment/treatment systems were derived from the Groundwater Monitoring Program analyte list, but it should be noted that these are different for the different systems.

Table 4.1.2.1-1 - Elevation of Shell Trench Bottoms

Bore ID	Ground Elevation, ft	Depth to Bottom of Trench, ft	Trench Bottom Elevation, ft
3178	5251.02	9	5242.02
3444	5248.1	4	5244.1
3445	5248.5	8	5240.5
3446	5248.6	8	5240.6
3453	5246.7	9	5237.7
3457	5249.8	9	5240.8

Table 6.4.1.1-1 Precipitation data[1] on RMA for water years 1999 through 2004

Month	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
October	0.88	0.58	0.50	0.17	0.83	0.04
November	0.49	0.43	0.71	0.87	0.40	0.13
December	0.44	0.16	0.06	0.26	0.00	0.28
January	0.28	0.00	0.67	0.71	0.00	0.33
February	0.04	3.22	0.46	0.65	0.36	0.42
March	0.36	1.58	0.83	0.83	2.26	0.22
April	5.36	0.72	1.19	0.08	2.84	2.66
May	1.37	1.94	3.76	1.58	2.43	1.03
June	2.19	0.92	0.94	0.79	2.29	1.77
July	3.56	1.46	2.08	1.28	1.42	3.61
August	2.40	3.06	1.14	1.23	2.62	2.91
September	0.92	1.36	0.84	1.42	0.19	2.04
Total	18.29	15.43	13.18	9.87	15.64	15.44

[1]All precipitation data are shown in units of inches of water, measured as total water-equivalent precipitation for the indicated month.

Table 6.4.1.2-1 - On-Post Tracking and Confined Flow System Water Quality Wells

Site ID	Location	Purpose	Purpose start	Justification	Analytes
01067	South Plants	CFS	12/1/1999		CL, 12DCE, CHCL3, DLDRN
01078	South Plants	Tracking	6/1/2003	South Plants source area monitoring	CHCL3, DLDRN
01102	South Plants	CFS	12/1/1999		CL, C6H6, CHCL3, CLC6H5, CPD
01109	South Plants	CFS	12/1/1999		CL, C6H6, CHCL3, DBCP
01300	South Plants	CFS	12/1/1999		CL, C6H6, CHCL3, DBCP, LDRN
01525[1]	South Plants	Tracking	6/1/2003	South Plants source area monitoring	CHCL3, DLDRN
01534	South Plants	Tracking	6/1/2003	South Plants source area monitoring	C6H6, CHCL3
02034	South Lakes	Tracking	6/1/2003	Between South Plants and Lake Ladora	C6H6, CHCL3, DLDRN
02056	South Lakes	Tracking	6/1/2003	Upgradient of Lake Mary	C6H6, CHCL3, DLDRN
02057	South Plants	CFS	12/1/1999		CL, 11DCLE, C6H6, CLC6H5, TRCLE, ALDRN, CPMSO2
02505	South Lakes	Tracking	6/1/2003	Between South Plants and Lake Ladora	C6H6, CHCL3, DLDRN
02512	South Lakes	Tracking	6/1/2003	Between South Plants and Lake Ladora	C6H6, CHCL3, DLDRN
02524	South Lakes	Tracking	6/1/2003	Between South Plants and Lake Ladora	C6H6, CHCL3, DLDRN
02525	South Lakes	Tracking	6/1/2003	Between South Plants and Lake Ladora	C6H6, CHCL3, DLDRN
03016[2]	NWBCS	Tracking	6/1/2003	Downgradient from Lake Mary	CHCL3, DLDRN
03503[3]	Rail Yard	Tracking	6/1/2003	East of Rail Yard extraction wells	DBCP
03523[3]	Rail Yard	Tracking	6/1/2003	Upgradient from Rail Yard	DBCP
23095	NBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upg	CL, CHCL3, DLDRN, DIMP, NNDMEA
23096	NBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upg	CL, CHCL3, DLDRN, DIMP, NNDMEA
23142	NBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upg	CL, CHCL3, DLDRN, DIMP, NNDMEA
23187	Basin F	CFS	12/1/1999		CL, DIMP

[1] Also monthly water quality sampling for the South Lakes project
[2] Also sampled in 2001 for OCPs
[3] Also sampled annually for Railyard operational water quality

Table 6.4.1.2-1 - On-Post Tracking and Confined Flow System Water Quality Wells

Site ID	Location	Purpose	Purpose start	Justification	Analytes
23193[4]	Basin F	CFS	12/1/1999		AS, CL, DLDRN, DIMP
24094	NBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upg	12DCLE, 111TCE, CCL4, CHCL3, DLDRN, DIMP
25059	North Plants	Tracking	6/1/2003	North Plants source area monitoring	12DCLE, 111TCE, CCL4, CHCL3, DLDRN, DIMP
25502[5]	Sec36/ Bedrock Ridge	Tracking	6/1/2003	Upgradient from North Plants	C6H6, CHCL3, DBCP, DLDRN, DITH
25503	Sec36/ Bedrock Ridge	Tracking	6/1/2003	Downgradient from Bedrock Ridge extraction wells	12DCLE, C6H6, CCL4, CHCL3, TCLEE, TRCLE, PPDDT, DIMP
25504	Sec36/ Bedrock Ridge	Tracking	6/1/2003	Downgradient from Bedrock Ridge extraction wells	12DCLE, C6H6, CCL4, CHCL3, TCLEE, TRCLE, PPDDT, DIMP
26006	Basin A Neck	Tracking	6/1/2003	NDMA monitoring downgradient from system	NNDMEA
26015[6]	Basin F	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient of NBCS	CL, CHCL3, DLDRN, DIMP, NNDMEA
26017[6]	Basin F	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient of NBCS	CL, CHCL3, DLDRN, DIMP, NNDMEA
26147	Basin F	CFS	12/1/1999		AS, CL, DLDRN, DIMP
26150	Basin F	CFS	12/1/1999		CL, DIMP
26152	Basin F	CFS	12/1/1999		CL, DLDRN, CPMSO2, DIMP
26153[7]	Basin F	CFS	12/1/1999		CL, DLDRN, DIMP
26157[7]	Basin F	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	CL, CHCL3, DLDRN, DIMP, NNDMEA
26163[6]	Basin F	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient of NBCS	CL, CHCL3, DLDRN, DIMP, NNDMEA

[4] Not sampled in FY04 because of partial obstruction at about 60 feet below ground surface. Well could not be repaired.
[5] Also sampled in FY01 for OCPs
[6] Also sampled annually for Basin F background water quality
[7] Also sampled in FY00 for Basin F background water quality

Table 6.4.1.2-1 - On-Post Tracking and Confined Flow System Water Quality Wells

Site ID	Location	Purpose	Purpose start	Justification	Analytes
26500	Basin A Neck	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	C6H6, CHCL3, DBCP, DLDRN, DIMP
27025	NWBCS	Tracking	6/1/2003	Downgradient from BANCS	CHCL3, DLDRN, DIMP, NNDMEA
27037	NWBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	CHCL3, DLDRN, DIMP
27072[8]	NWBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	CHCL3, DLDRN, DIMP
27079	NWBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	CHCL3, DLDRN, DIMP
27082	NWBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	CHCL3, DLDRN, DIMP
27083	NWBCS	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	CHCL3, DLDRN, DIMP
27500[8]	NWBCS	Tracking	6/1/2003		CHCL3, DLDRN, DIMP
27522	NWBCS	Tracking	6/1/2003	South Plants dieldrin plume definition	CHCL3, DLDRN, DIMP
28520[9]	NWBCS	Tracking	6/1/2003	South Plants dieldrin plume definition	CHCL3, DLDRN, DIMP
28522[9]	NWBCS	Tracking	6/1/2003	South Plants dieldrin plume definition	CHCL3, DLDRN, DIMP
33341[10]	Irondale	Tracking	6/1/2003	Monitoring TCE from off-post source	TRCLE
34020	NWBCS	Tracking	6/1/2003	Downgradient from South Plants	CHCL3, DLDRN
35058[11]	NWBCS	Tracking	6/1/2003	Downgradient from Sand Creek Lateral	CHCL3, DLDRN
35063	Basin A	CFS	12/1/1999		AS, CL
35065	Basin A Neck	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	C6H6, CHCL3, DBCP, DLDRN, DIMP
35067	Basin A	CFS	12/1/1999		CL, C6H6, TCLEE, DLDRN, CPMSO2, DIMP

[8] Also sampled quarterly for NWBCS operational water quality
[9] Sampled annually for NWBCS operational water quality. CHCL3 and DIMP were not analyzed because they were not included in the Operational analyte list.
[10] Also sampled in 200 and 2001 for VOCs
[11] Well was damaged by tilling operations in summer 2004. The well was sampled in October 2004, after it was repaired.

Table 6.4.1.2-1 - On-Post Tracking and Confined Flow System Water Quality Wells

Site ID	Location	Purpose	Purpose start	Justification	Analytes
35068	Basin A	CFS	12/1/1999		AS, CL, C6H6, TCLEE, DLDRN, CPMSO, DIMP
35069	Basin A Neck	Tracking	6/1/2003	Indicator analyte monitoring at plume transect upgradient	C6H6, CHCL3, DBCP, DLDRN, DIMP
35083	South Plants	CFS	12/1/1999		CL, CCL4, CHCL3, TCLEE
36113	Basin A	CFS	12/1/1999		CL, CHCL3, DLDRN, DITH, DIMP
36114	Basin A	CFS	12/1/1999		CL, DITH, DIMP
36159	Basin A	CFS	12/1/1999		CL, DIMP
36171	Basin A	CFS	12/1/1999		AS, CL, CLC6H5, CHCL3, DIMP
36183	South Plants	CFS	12/1/1999		CL, 12DCLE, C6H6, CLC6H5, CHCL3, DBCP, TRCLE
36552	Sec36/ Bedrock Ridge	Tracking	6/1/2003	West edge of Bedrock Ridge plume	12DCLE, C6H6, CCL4, CHCL3, TCLEE, TRCLE, PPDDT, DIMP
36594	Sec36/ Bedrock Ridge	Tracking	6/1/2003	Bedrock Ridge plume	12DCLE, C6H6, CCL4, CHCL3, TCLEE, TRCLE, PPDDT, DIMP

Table 6.4.1.3-1 Chloride Concentrations in CFS Wells 36067 and 35083.

Well	Year	Chloride Concentration, µg/L
35067	1994	180,000
	1997	220,000
	1999	230,000
	2002	270,000
	2004	330,000
35083	1993	43,000
	2002	810,000
	2004	940,000

Table 6.4.1.5-1 - Off-Post CSRG Exceedance Well Network

Site ID	Purpose Start	Location	LTMP Analytes
37008	12/1/1999	Downgradient from Northern Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37009	12/1/1999	Downgradient from Northern Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37010	12/1/1999	Downgradient from Northern Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37011	12/1/1999	Downgradient from Northern Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37012	12/1/1999	Downgradient from Northern Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37013	12/1/1999	Downgradient from Northern Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37027	12/1/1999	South end of Northern Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37039	12/1/1999	South end of Northern Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37040	12/1/1999	E 104 Ave plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, DLDRN
37041	12/1/1999	Downgradient from First Creek Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37062	12/1/1999	Near First Creek Pathway Intercept	CL, F, SO4, 12DCLE, 13DCLB,CCL4,CLC6H5,CHCL3,TCLEE,TRCLE, DIMP
37065	12/1/1999	Near First Creek Pathway Intercept	CL, F, SO4, DCPD, 12DCLE, 13DCLB,CCL4,CLC6H5,CHCL3,TCLEE,TRCLE, DIMP, NNDMEA
37070	12/1/1999	Downgradient from First Creek Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37071	12/1/1999	Near First Creek Pathway Intercept	CL, F, SO4, 12DCLE, 13DCLB,CCL4,CLC6H5,CHCL3,TCLEE,TRCLE, DIMP
37074	12/1/1999	Upgradient from First Creek Pathway Intercept	CL, F, SO4, DLDRN, DIMP
37076	12/1/1999	Upgradient from First Creek Pathway Intercept	CL, F, SO4, 12DCLE, 13DCLB,CCL4,CLC6H5,CHCL3,TCLEE,TRCLE, DIMP
37080	12/1/1999	Hwy 2 plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, DIMP
37081	12/1/1999	First Creek Pathway downgradient from NBCS	CL, F, SO4, DLDRN, DIMP
37083	12/1/1999	Upgradient from First Creek Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37084	12/1/1999	Downgradient from First Creek Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37094	12/1/1999	Hwy 2 plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, 12DCLE, 13DCLB,CCL4,CLC6H5,CHCL3,TCLEE,TRCLE, DLDRN, DIMP
37095	12/1/1999	Hwy 2 plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, DBCP, 12DCLE, 13DCLB, CCL4, CLC6H5, CHCL3, TCLEE, TRCLE, DIMP
37097	12/1/1999	Downgradient from First Creek Pathway Intercept	DIMP
37107	12/1/1999	Upgradient from First Creek Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37108	12/1/1999	First Creek Pathway	DIMP
37110	12/1/1999	Downgradient from First Creek Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37125	12/1/1999	Downgradient from NWBCS	CHCL3, DLDRN
37126	12/1/1999	Downgradient from NBCS	CL, F, SO4, DLDRN, DIMP
37318	12/1/1999	Upgradient of First Creek Pathway	CL, F, SO4, DIMP

Table 6.4.1.5-1 - Off-Post CSRG Exceedance Well Network

Site ID	Purpose Start	Location	LTMP Analytes
37320	12/1/1999	E 104 Ave plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, ALDRN, CLDAN, PPPPDDE, PPPPDDT, DLDRN, ENDRN, ISODR, DIMP
37342	12/1/1999	North of First Creek Pathway	CL, F, SO4, DIMP
37343	12/1/1999	Downgradient from First Creek Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37347	12/1/1999	First Creek Pathway	DIMP
37349	12/1/1999	First Creek Pathway	DIMP
37351	12/1/1999	Near E 104 Ave and Brighton Rd	F, CHCL3, DIMP
37353	12/1/1999	First Creek Pathway	DIMP
37355	12/1/1999	Near E 104 Ave and Brighton Rd; well was destroyed	CL, F, TCLEE, DIMP
37356	12/1/1999	First Creek pathway; well was destroyed	DIMP
37367	12/1/1999	E 104 Ave plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, 12DCLE, 13DCLB, CCL4, CLC6H5, CHCL3, TCLEE, TRCLE, DIMP
37368	12/1/1999	Upgradient from Northern Pathway Intercept	CL, F, SO4, DBCP, 12DCLE, 13DCLB, CCL4, CLC6H5, CHCL3, TCLEE, TRCLE, DIMP
37369	12/1/1999	First Creek pathway downgradient from NBCS	CL, F, SO4, ALDRN, CLDAN, PPPPDDE, PPPPDDT, DLDRN, ENDRN, ISODRN, DIMP
37370	12/1/1999	Upgradient from Northern Pathway Intercept	CL, F, SO4, DLDRN, DIMP
37374	12/1/1999	Southwest of Northern Pathway Intercept	CL, F, SO4, CHCL3, DIMP
37377	12/1/1999	Plume transect downgradient from NBCS	CL, F, SO4, DIMP
37378	12/1/1999	Plume transect downgradient from NBCS	CL, F, SO4, DLDRN
37379	6/1/2003	Southwest of Northern Pathway Intercept; vertical profile	CL, F, SO4, CHCL3, DIMP
37380	6/1/2003	Southwest of Northern Pathway Intercept; vertical profile	CL, F, SO4, CHCL3, DIMP
37389	12/1/1999	Plume transect downgradient from NBCS	CL, F, SO4, TCLEE, DIMP
37391	12/1/1999	Plume transect downgradient from NBCS	CL, F, SO4, 12DCLE, 13DCLB,CCL4,CLC6H5,CHCL3,TCLEE,TRCLE, DIMP
37391	6/1/2003	NDMA monitoring	NNDMEA
37392	12/1/1999	Plume transect downgradient from NBCS	CL, F, SO4, DLDRN, DIMP
37395	12/1/1999	Hwy 2 plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, DBCP, 12DCLE, 13DCLB,CCL4,CLC6H5,CHCL3,TCLEE,TRCLE, DLDRN, DIMP
37396	12/1/1999	Downgradient from First Creek Pathway Intercept	AS, CL, F, SO4, 12DCLE, 13DCLB, C6H6, CCL4, CLC6H5, CHCL3, DBCP, DCPD, ETC6H5, TCLEE,
			TRCLE, MEC6H5, XYLEN, CL6CP, ALDRN, CLDAN, PPDDE, PPDDT, DLDRN, ENDRN, ISODR, MLTHN,
			CPMS, CPMSO2, CPMSO, DITH, DIMP, NDMA, ATZ
37403	12/1/1999	E 104 Ave plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, DLDRN, DIMP
37404	12/1/1999	Hwy 2 plume transect upgradient from Northern Pathway Intercept	CL, F, SO4, CHCL3, DIMP
37407	12/1/1999	Downgradient from Northern Pathway Intercept	CL, F, SO4, TCLEE, TRCLE, DIMP
37428	12/1/1999	First Creek Pathway	DIMP
37429	12/1/1999	First Creek Pathway	DIMP
37430	12/1/1999	Near E 104 Ave and Brighton Rd	F, CHCL3, DIMP
PRIVATE WELLS SAMPLED BY TRICOUNTY HEALTH DEPARTMENT			
359C	6/1/2003	1st alternate for 986A; Section 9/10 DIMP exceedance area; alternate for 37355	CL, F, TCLEE, DIMP
489B	12/1/1999	Downgradient from NBCS	DIMP
494C	12/1/1999	First Creek Pathway	DIMP
538A	6/1/2003	Substitute for 37357	DIMP
548B	6/1/2003	Substitute for well 37356 and alternate to 555B and 555C	DIMP
562A	12/1/1999	Northeast of First Creek Pathway; Outside of DIMP exceedance area	DIMP
844B	12/1/1999	North of Northern Pathway Intercept; Outside of DIMP exceedance area	DIMP
986A	12/1/1999	West of First Creek Pathway; 1st substitute for 37355	DIMP
1178D	3/31/2004	First Creek Pathway	DIMP
1185B	12/1/1999	First Creek Pathway	DIMP
1185C	12/1/1999	First Creek Pathway	DIMP
1438C	12/1/1999	Downgradient frm Northern Pthwy Intercept; Outside of DIMP exceedance area	DIMP

TABLE 6.4.2.1-1 - Summary of Surface Water Detections in First Creek 1999 through 2004

Target Analyte	CBSMSW[10] (PQL[12]), µg/L	CSRG[11] (PQL[12]), µg/L	Reporting Limit range (µg/L)	SW24002 First Creek above 96th Avenue, at Rocky Mountain Arsenal			SW24004 First Creek at the North Rocky Mountain Arsenal Boundary			SW37001 First Creek at Highway 2, near Rocky Mountain Arsenal		
				Range of Detected Values (µg/L)	Number of samples above CBSMSW/ Number of Samples Collected	Number of samples above CSRG/ Number of Samples Collected	Range of Detected Values (µg/L)	Number of samples above CBSMSW/ Number of Samples Collected	Number of samples above CSRG/ Number of Samples Collected	Range of Detected Values (µg/L)	Number of samples above CBSMSW/ Number of Samples Collected	Number of samples above CSRG/ Number of Samples Collected
Arsenic	50	2.35	2.0-10	1.6 – 4.56	0/8	3/8	2.35-4.34	0/4	2/4	1.32[19] – 4.9	0/7	3/7
Chloride	250,000	250,000	1,000 – 1,000	28,000 – 120,000	0/8	0/8	27,000 – 100,000	0/4	0/4	33,000 – 440,000	2/7	2/7
Fluoride[1]	2,000	2,000	100 - 134	434 – 1,320	0/8	0/8	462 – 1,220	0/4	0/4	486 – 1,620	0/5	0/5
Sulfate	250,000	540,000	2,500 – 2,500	87,000 – 260,000	1/8	0/8	77,000 – 240,000	0/4	0/4	93,000 – 660,000	4/7	1/7
DIMP[2]	8	8	1.0 – 1.0	ND[3]	0/3	0/3[14]	ND[3]	0/4	0/4	2.01 - 49	2/7	2/7
DCPD[4]	N/A[13]	46	0.2 – 5.0	ND[3]	N/A[13]	0/8	ND[3]	N/A[13]	0/4	0.664 – 0.664	N/A[13]	0/7
Alpha-Chlordane[5]	0.1[15] (1.0)[15]	0.03[17] (0.095)[17]	0.024 – 0.024	ND[3]	0/8	0/8	ND[3]	0/4	0/4	ND[3]	0/7	0/7
Gamma-Chlordane[5]	0.1[16] (1.0)[16]	0.03[18] (0.095)[18]	0.012 – 0.022	ND[3]	0/8	0/8	ND[3]	0/4	0/4	ND[3]	0/7	0/7
PPDDE[6]	0.1	0.1	0.024 – 0.034	ND[3]	0/8	0/8	ND[3]	0/4	0/4	0.0575 – 0.0583[20]	0/7	0/7
PPDDT[7]	0.1	0.1	0.039 – 0.043	ND[3]	0/8	0/8	ND[3]	0/4	0/4	ND[3]	0/7	0/7
Dieldrin	0.002 (0.1)	0.002 (0.05)	0.04 – 0.048	ND[3]	0/8	0/8	ND[3]	0/4	0/4	ND[3]	0/7	0/7
1,2DCLE[8]	0.4	0.4	0.2 - 0.299	ND[3]	0/8	0/8	ND[3]	0/4	0/4	ND[3]	0/5	0/5
TCLEE[9]	5	5	0.2 – 0.2	ND[3]	0/8	0/8	ND[3]	0/4	0/4	ND[3]	0/5	0/5

Notes:

[1]Fluoride data shown are for ion-specific methods (3402 and TU06) only. Other fluoride methods (TT22 and TT23) are affected by interferences from other analytes.
[2]DIMP – Diisopropyl methylphosphonate.
[3]ND – Not detected.
[4]DCPD – Dicyclopentadiene.
[5]Alpha-chlordane and gamma-chlordane are the two main isomers of chlordane.
[6]PPDDE – 2,2-bis(p-chlorophenyl)-1,1-dichloroethane.
[7]PPDDT – 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane.
[8]12DCLE – 1,2-dichloroethane.
[9]TCLEE – tetrachloroethylene.
[10]CBSMSW Colorado Basic Standards and Methodologies for Surface Water, a human health based standard for water supply (5 CCR 1002-31, 2001).
[11]CSRG Containment System Remediation Goal.
[12]PQL Practical Quantitation Limit
[13]N/A – not applicable because there is not a CBSMSW for DCPD.
[14]DIMP was deleted from sampling plan after June 2001 in accordance with the Surface Water Sampling and Analysis Plan (Foster Wheeler Environmental Corporation, July 13, 2001).
[15]CBSMSW chlordane standard.
[16]CBSMSW chlordane standard.
[17]CSRG chlordane goal.
[18]CSRG chlordane goal.
[19]Filtered sample value; lowest non-filtered sample value was 1.87 µg/L.
[20]Duplicate sample value.

Table 7.2.2.1-1 - Off-Post Mass Removal FY2000 through FY2004

Analyte	Total Mass Removed (lbs)
DIMP	162.6
DCPD	10.8
Chloroform	6.8
Tetrachloroethylene	4.9
Chlorophenylmethyl sulfoxide (CPMSO)	4.1
DBCP	0.5
Chloromethane	0.3
Endrinketone	0.15
Dichlorodiphenyltrichloroethene (DDT)	0.1
1,2-DCE	0.09
Dichlorodiphenyldichloroethene (DDE)	0.05
Endrin	0.01
Heptachlorepoxide	0.003
TOTAL ANALYTE MASS	190.4

Table 7.2.2.2-1 Water Quality Data from the Offpost Private Well Network 2000 through 2004

Private Well ID	Aquifer	Sample Date	DIMP (Micrograms per liter) (LT=Less than)	Chloroform (Micrograms per liter) (LT=Less than)
359A	Arapahoe	6/28/2000	4.02	
		6/6/2001	4.24	
		7/9/2002	3.69	
		7/14/2003	1.01	
		6/29/2004	2.72	
376A	Arapahoe	6/24/2003	LT 0.35	
		6/15/2004	LT 0.35	
544A	Arapahoe	7/10/2002	LT 0.35	
		8/18/2004	LT 0.35	
545A	Arapahoe	8/12/2002	LT 0.35	
		6/15/2004	LT 0.35	
548A	Arapahoe	7/9/2002	LT 0.35	
		7/14/2004	LT 0.35	
848A	Arapahoe	6/29/2000	1.74	
		6/13/2001	LT 0.35	
		8/3/2001	1.11	
		7/16/2002	0.708	
		6/10/2003	LT 0.35	
		6/30/2004	LT 0.35	
914B	Arapahoe	5/25/2000	1.75	
		7/10/2001	3.6	LT 0.2
		7/16/2002	3.11	
		6/16/2003	2.51	
		7/6/2004	2.67	
986B	Arapahoe	7/8/2002	LT 0.35	
		6/17/2004	LT 0.35	
1070B	Arapahoe	6/14/2000	4.91	
		7/10/2001	3.53	0.447
		7/2/2002	3.54	
		6/9/2003	2.7	
		7/30/2003	2.88	LT 0.2
		7/7/2004	1.86	
1171A	Arapahoe	7/18/2000	3.65	
		9/24/2001	2.53	
		9/10/2002	LT 0.35	
		7/13/2004	1.14	

Table 7.4.1.1-1 - Updated Quantitation Limits for Water Treatment Systems

System	Chemical	Quantitation Limit	2005 CSRG (µg/L)	2000 Quantitation Limit (µg/L)\	2005 Quantitation Limit (µg/L)
NWBCS					
	Dieldrin	MRL	0.002	0.05	0.05
	NDMA	MRL	0.0069	0.033	0.033
NBCS					
	Aldrin	MRL	0.0021	0.025	0.037
	Carbon Tetrachloride	MRL	0.27	0.488	0.488
	Dieldrin	MRL	0.002	0.05	0.05
	NDMA	MRL	0.00069	0.033	0.033
OGITS					
	Aldrin	MRL	0.0021	0.025	0.037
	Carbon Tetrachloride	MRL	0.27	0.488	0.488
	Dieldrin	MRL	0.002	0.05	0.05
	NDMA	MRL	0.00069	0.033	0.033
BANCS					
	Carbon tetrachloride	System-Specific PQL	0.27	1	1
	1,2-Dichloroethane	System-Specific PQL	0.38	1.1	1.1
	Dieldrin	System-Specific PQL	0.002	0.1	0.1
CERCLA WWTU					
	Aldrin	Colo PQL	0.0021	0.025	0.1
	Carbon tetrachloride	System-Specific PQL	0.27	0.488	1.0
	DDE	Colo PQL	0.1	Not Evaluated	0.1
	1,2-Dichloroethane	System-Specific PQL	0.38	0.2	1.1
	1,2 Dichloropropane	Colo PQL	0.52	Not Evaluated	1.0
	Dieldrin	System-Specific PQL	0.002	0.05	0.1
	Vinyl chloride	Colo PQL	0.023	Not Evaluated	2
LTWU					
	Mercury	Colo PQL	0.01	0.2	No Colo PQL listed, MRL = 0.2[1].
	Aldrin	Colo PQL	$4.9x10^{-5}$	0.1	0.1
	Acenaphthylene	Colo PQL	$2.8x10^{-3}$	10	10
	Atrazine	Colo PQL	3	4	1
	Benzo(a)anthracene	Colo PQL	$3.8x10^{-3}$	10	10
	Benzo(a)pyrene	Colo PQL	$3.8x10^{-3}$	10	0.2
	Benzo(k)fluoranthene	Colo PQL	$3.8x10^{-3}$	10	10
	3,4 Benzofluoranthene	Colo PQL	$4.4x10^{-3}$	10	No Colo PQL listed, MRL = 10[1]
	Bis (2-chloroethyl) ether	Colo PQL	0.03	10	1.0
	Carbon tetrachloride	Colo PQL	0.23	1	1
	Chlordane	Colo PQL	$8x10^{-4}$	1	1
	Chrysene	Colo PQL	$3.8x10^{-3}$	10	10
	DDD	Colo PQL	$3.1x10^{-4}$	0.1	0.1

Table 7.4.1.1-1 - Updated Quantitation Limits for Water Treatment Systems

System	Chemical	Quantitation Limit	2005 CSRG (µg/L)	2000 Quantitation Limit (µg/L)\	2005 Quantitation Limit (µg/L)
LTWU					
	DDE	Colo PQL	$2.2x10^{-4}$	0.1	0.1
	DDT	Colo PQL	$2.2x10^{-4}$	0.1	0.1
	Dibenzo(a,h) anthracene	Colo PQL	$3.8x10^{-3}$	10	10
	Dibromochloro propane	Colo PQL	0.2	1	0.5
	1,2 Dichloroethane	Colo PQL	0.38	1	1
	1,1 Dichloro-ethene	Colo PQL	7	1	1
	2,4 Dichlorophenol	Colo PQL	21	50	50
	1,2 Dichloropropane	Colo PQL	0.50	1	1
	Dieldrin	Colo PQL	$5.2x10^{-5}$	0.1	0.1
	Endosulfan, Alpha	Colo PQL	0.056	0.1	0.1
	Endrin	Colo PQL	0.036	0.1	0.1
	Heptachlor	Colo PQL	$7.8x10^{-5}$	0.05	0.05
	Heptachlor epoxide	Colo PQL	$3.9x10^{-5}$	0.05	0.05
	Hexachloro-butadiene	Colo PQL	0.44	10	10
	Hexachloroethane	Colo PQL	0.4	10	10
	Indeno (1,2,3-cd) pyrene	Colo PQL	$3.8x10^{-3}$	10	10
	Malathion	Colo PQL	0.1	1	Colo PQL = 0.2 by GC
	Methoxychlor	Colo PQL	0.03	0.5	0.5
	NDMA	Colo PQL	$6.9x10^{-4}$	1	10
	Parathion	Colo PQL	0.013	No PQL listed	No Colo PQL listed, MRL = 0.259[1]
	Pentachlorophenol	Colo PQL	0.27	10	1
	1,1,2,2 Tetrachloroethane	Colo PQL	0.17	1	1
	Tetrachloroethene	Colo PQL	0.69	1	1
	Vinyl chloride	Colo PQL	0.023	No PQL listed	2

[1]ARMY MRLs will be applied until such time that Colorado includes this constituent in the PQL guidance.

[2]During the comment resolution process on the Five Year Review Report MRLs less than the CSRGs have been achieved for carbon tetrachloride and 1,2-Dichloroethane.

[3]During the comment resolution process on the Five Year Review Report a process for determining site-specific PQLs has been approved on October 26, 2006 and documented in a Decision Document DD-RMAPQL-11.

Table 7.4.1.2-1 – ARAR Changes for the Northwest Boundary Containment System

Compound	Citation[1]	Old µg/L	New µg/L	Comment/Action
Chloroform	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	6	3.5	The new limit was promulgated March 22, 2005
NDMA	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.007	0.00069[2]	The new limit was promulgated December 30, 2001

[1]The citation numbers for CBSGs have changed since the On-Post ROD was issued.

CCR = Code of Colorado Regulations.

[2]The Table 7.4.1.1-1 quantitation limit is higher than the ARAR.

Table 7.4.1.2-2 – ARAR Changes for the North Boundary Containment System

Compound	Citation[1]	Old µg/L	New µg/L	Comment/Action
Carbon Tetrachloride	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.3	0.27[2]	The new limit was promulgated December 30, 2001
Chloroform	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	6	3.5	The new limit was promulgated March 22, 2005
1,2 Dichloro-ethane	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.4	0.38[2]	The new limit was promulgated December 30, 2001
Methylene chloride	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	5	4.7	The mew limit was promulgated December 30, 2001
NDMA	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.007	0.00069[2]	The new limit was promulgated December 30, 2001

[1] *The citation numbers for CBSGs have changed since the On-Post ROD was issued. CCR = Code of Colorado Regulations. CMCL = Colorado Maximum Contaminant Level*

[2] *The Table 7.4.1.1-1 quantitation limit is higher than the ARAR.*

Table 7.4.1.2-3 – ARAR Changes for the Off-Post Groundwater Intercept and Treatment System

Compound	Citation[1]	Old µg/L	New µg/L	Comment/Action
Carbon tetrachloride	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.3	0.27[2]	The new limit was promulgated December 30, 2001
Chlordane	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.03	0.1	The new limit was promulgated December 30, 2001
Chloroform	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	6	3.5	The new limit was promulgated March 22, 2005
1,2 dichloro-ethane	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.4	0.38[2]	The new limit was promulgated December 30, 2001
NDMA	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.007	0.00069[2]	The new limit was promulgated December 30, 2001

[1] *The citation numbers for CBSGs have changed since the On-Post ROD was issued. CCR = Code of Colorado Regulations.*

[2] *The Table 7.4.1.1-1 quantitation limit is higher than the ARAR.*

Table 7.4.1.2-4 – ARAR Changes for the Basin A Neck Containment System

Compound	Citation[1]	Old µg/L	New µg/L	Comment/Action
Carbon tetrachloride	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.3	0.27[2]	The new limit was promulgated December 30, 2001
Chloroform	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	6	3.5	The new limit was promulgated March 22, 2005
1,2 Dichloro-ethane	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.4	0.38[2]	The new limit was promulgated December 30, 2001
Hexachloro-cyclopentadiene	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	50	42	The new limit was promulgated March 22, 2005

[1] *The citation numbers for CBSGs have changed since the On-Post ROD was issued. CCR = Code of Colorado Regulations.*

[2] *The Table 7.4.1.1-1 quantitation limit is higher than the ARAR.*

Table 7.4.1.2-5 – ARAR Changes for the CERCLA Wastewater Treatment Unit

Compound	Citation[1]	Old µg/L	New µg/L	Comment/Action
Aldrin	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	0.1	0.0021[2]	The new limit was promulgated December 30, 2001
Carbon Tetrachloride	Old: 40 CFR §141.11(b) - MCL; New: 5 CCR 1002-41 CBSG	4	0.27[2]	The new limit was promulgated December 30, 2001
Chlorobenzene	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	300	100	The new limit was promulgated December 30, 2001
Chloroform	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	6	3.5	The new limit was promulgated March 22, 2005
1,2 Dichloro-ethane	Old: 40 CFR §141.61(a) - MCL; New: 5 CCR 1002-41 CBSG	5	0.38[2]	The new limit was promulgated December 30, 2001
trans-1,2 dichloro ethylene	Old: 40 CFR §141.61(a) - MCL; New: 5 CCR 1002-41 CBSG	7	100	The new limit was promulgated March 2, 1999
1,2 Dichloro-propane	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	6	0.52[2]	The new limit was promulgated March 2, 1999
DIMP	New: 5 CCR 1002-41 CBSG	No STD	8	The new limit was promulgated January 31, 1994
Hexachloro-cyclopentadiene	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	49	42	The new limit was promulgated March 22, 2005
Methylene chloride	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	5	4.7	The new limit was promulgated December 30, 2001
Tetrachloro-ethene	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	10	5	The new limit was promulgated March 2, 1999
Toluene	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	2420	1000	The new limit was promulgated March 2, 1999
1,1,2-Trichloro-ethane	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	28	2.8	The new limit was promulgated March 22, 2005
Vinyl chloride	Old: 5 CCR 1002-8, CBSG; New: 5 CCR 1002-41 CBSG	2	0.023[2]	The new limit was promulgated March 22, 2005

[1] *The citation numbers for CBSGs have changed since the On-Post ROD was issued. CCR = Code of Colorado Regulations.*

[2] *The Table 7.4.1.1-1quantitation limit is higher than the ARAR.*

Table 7.4.1.2-6 – ARAR Changes for the Landfill Wastewater Treatment Unit 30-day Average (Chronic) Limits[1]

Compound	Citation[2]	Old µg/L	New µg/L	Comment/Action
Aldrin	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.00013	0.000049[3]	The new limit was promulgated on August 15, 2000
Benzene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	1.2	2.2	The new limit was promulgated on August 15, 2000
Benzo(a)anthrax-cene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.0044	0.0038[3]	The new limit was promulgated on August 15, 2000
Benzo(a)pyrene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.0044	0.0038[3]	The new limit was promulgated on August 15, 2000
Benzo(k)fluor-anthene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.0044	0.0038[3]	The new limit was promulgated on August 15, 2000
Bis (2-Chloroethyl) ether	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.031	0.030[3]	The new limit was promulgated on August 15, 2000
Carbon Tetrachloride	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.25	0.23[3]	The new limit was promulgated on August 15, 2000
Chlordane	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.0021	0.0008[3]	The new limit was promulgated on August 15, 2000
Chloroform	New 5 CCR 1002-31, CBSMSW	Report	3.4	The new limit was promulgated on August 15, 2000
Chrysene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.0044	0.0038[3]	The new limit was promulgated on August 15, 2000
DDD	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.00083	0.00031[3]	The new limit was promulgated on August 15, 2000
DDE	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.00059	0.00022[3]	The new limit was promulgated on August 15, 2000
DDT	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.00059	0.00022[3]	The new limit was promulgated on August 15, 2000
Dibenzo(a,h) anthracene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.0044	0.0038[3]	The new limit was promulgated on August 15, 2000
1,2 Dichlorobenzene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	600	420	The new limit was promulgated on August 15, 2000
1,3 Dichlorobenzene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	400	94	The new limit was promulgated on August 15, 2000
1,4 Dichlorobenzene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	75	63	The new limit was promulgated on August 15, 2000
1,1 Dichloroethylene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.057	7	The new limit was promulgated on August 15, 2000. No longer a quantitation issue.
Dichloromethane	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	4.7	4.6	The new limit was promulgated on August 15, 2000
1.2 Dichloropropane	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.52	0.50[3]	The new limit was promulgated on August 15, 2000
Dieldrin	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.00014	0.000052[3]	The new limit was promulgated on August 15, 2000
Ethylbenzene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	700	530	The new limit was promulgated on August 15, 2000
Endrin Aldehyde	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.76	0.29	The new limit was promulgated on August 15, 2000
Heptachlor	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.00021	0.000078[3]	The new limit was promulgated on August 15, 2000
Heptachlor epoxide	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.0001	0.000039[3]	The new limit was promulgated on August 15, 2000
Hexachloro-butadiene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.45	0.44[3]	The new limit was promulgated on August 15, 2000

Table 7.4.1.2-6 – ARAR Changes for the Landfill Wastewater Treatment Unit 30-day Average (Chronic) Limits[1]

Compound	Citation[2]	Old µg/L	New µg/L	Comment/Action
Hexachloroethane	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	7	0.4[3]	The new limit was promulgated on August 15, 2000
Indeno (1,2,3-cd) pyrene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.0044	0.0038[3]	The new limit was promulgated on August 15, 2000
Isophorone	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	36	130	The new limit was promulgated on August 15, 2000
Methyl chloride	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	5.7	5.6	The new limit was promulgated on August 15, 2000
Pentachlorophenol	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.28	0.27[3]	The new limit was promulgated on August 15, 2000
Tetrachloroethylene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	0.8	0.69[3]	The new limit was promulgated on August 15, 2000
1,1,2 Trichloro-ethane	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	3	2.7	The new limit was promulgated on August 15, 2000
Trichloroethylene	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	2.7	2.5	The new limit was promulgated on August 15, 2000
Vinyl chloride	Old: 5 CCR 1002-8, CBSMSW; New 5 CCR 1002-31, CBSMSW	2	0.023[3]	The new limit was promulgated on August 15, 2000

[1]*Human health-based limits for water and fish consumption*

[2]*The citation numbers for CBSMSWs have changed since the On-Post ROD was issued. CCR = Code of Colorado Regulations.*

[3]*The Table 7.4.1.1-1 quantitation limit is higher than the ARAR.*

Table 7.4.2-1 – ARAR Changes for Worker Exposure Standards, General

Contaminant in Air	Organization	ROD Listed Exposure Limit	New Exposure Limit	Source/Year	Mandatory?
Arsenic (inorganic)	ACGIH	TWA = 0.1 mg/m^3	0.01 mg/m^3	TLV Booklet, 2004	No
	OSHA	PEL = 10.0 mg/m^3 (8 hr TWA)	0.5 mg/m^3 (8 hr TWA)	29 CFR 1910 Subpart Z, 7/99	Yes
Benzene	ACGIH	TWA = 0.1 ppm, STEL = 0.3 mg/m^3 skin	TWA = 0.5 ppm, STEL = 2.5 ppm	TLV Booklet, 2004	No
Hydrazine	ACGIH	TWA = 0.1 ppm	TWA = 0.01 ppm	TLV Booklet, 2004	No
Vinyl chloride	ACGIH	TWA = 5 ppm, 13 mg/m^3	TWA = 1 ppm	TLV Booklet, 2004	No

ACGIH: American Conference of Government Industrial Hygienists

OSHA: Occupational Safety and Health Administration

mg/m^3: milligram per cubic meter

ppm: parts per million

STEL: short-term exposure limit

TLV: threshold limit value

CFR: Code of Federal Regulations

TWA: Time-Weighted Average

PEL: Permissible Exposure Limit

Table 7.4.2-2 – ARAR Changes for Worker Exposure Standards for Chemical Agent Constituents

Contaminant in Air, AR, or DA PAM	Organi-zation	ROD Listed Exposure Limit	New Exposure Limit	Source/Year	Manda-tory?
Adamsite	ARMY	LCt_{50}=11000-44000 mg-min/m^3	LCt_{50} (avg.)= 11000 mg-min/m^3	ARMY Detailed Chemical Fact Sheets, July 1998	No
Distilled Mustard (HD)	ARMY	PEL=0.003 mg/m^3 uw (8hr TWA) Ceiling=0.003 mg/m^3 uw =0.003 mg/m^3 (naw/gp) SEL=0.003 mg/m^3(1hr TWA) AEL=0.003 mg/m^3	AEL=0.0004 mg/m^3 (8hr TWA)	CDC, 69 FR 24164	Yes
GB (Sarin)	ARMY	AEL=0.0001 mg/m^3 (8hr TWA) AEL=0.2 mg/m^3 (any period)	AEL=0.00003 mg/m^3 (8hr TWA) STEL=0.0001 mg/m^3 (15-minute)	CDC, 68 FR 58348	Yes
H, HT	ARMY	AEL=0.003 mg/m^3	AEL=0.0004 mg/m^3 (8hr TWA) Ceiling= 0.003 mg/m^3 $\leq$ 15 min.	CDC, 69 FR 24164	Yes
Lewisite (L)		LCt_{50}=1200-1500 mg-min/m^3 (inhal) =100000 mg-min/m^3 (s/m) ICt_{50}= <300 mg-min/m^3 (eye injury-vapor) = >1500 mg-min/m^3 (s/m) Ceiling= 0.0001 mg/m^3 uw = 0.0001 mg/m^3 (naw/gp) SEL= 0.0001 mg/m^3(1hr TWA)	AEL = 0.003 mg/m^3 (8hr TWA)	ARMY Detailed Chemical Fact Sheets, July 1998	No
Mustard-Lewisite Mixture	ARMY	LCt_{50}=1500 mg-min/m^3 (inhal) >10000 mg-min/m^3 (s/m) ICt_{50}= 200 mg-min/m^3 (eye injury) = 1500-2000 mg-min/m^3 (s/m)	None. Refer to limits for individual compounds	N/A	No
VX	ARMY	AEL=0.00001 mg/m^3 (8hr TWA) AEL=0.02 mg/m^3 (any period)	AEL=0.000001 mg/m^3 (8hr TWA)	CDC, 68 FR 58348	Yes

Note: The original categories of ROD-listed exposure limits remain unaffected by the addition of new categories.

AR: Army Regulation
AEL: Airborne Exposure Limit
CDC: Centers for Disease Control
DA PAM: Department of Army Pamphlet
ICt_{50}: Median incapacitating dose
LCt_{50}: Median lethal dose
PEL: Permissible Exposure Limit
SEL: Source Emission Limit
STEL: Short Term Exposure Limit

Table 7.4.3-1 - TBC Changes for AIR - Chronic

Compound	Citation	Old-2001 ug/m³	New-2005 ug/m³	Comment/Action
Carcinogenic				
1,1 Dichloroethene	Old: 2001 IRIS New: 2004 IRIS	0.054	N/A	Cancer Slope Factor removed from IRIS by EPA
Tetrachloroethene	Old: 2001 IRIS New: 2004 EPA Region 3	4.7	0.47	
Non-Carcinogenic				
Benzene	Old: 1998 EPA-NCEA New: 2004 IRIS	6.0	30	
Carbon tetrachloride	Old: 1998 EPA-NCEA New: 2004 IRIS	2.0	2.5	
Chlorobenzene	Old: 1997 EPA540/R-97-036 New: 2004 IRIS	18	70	
Chloroform	Old: 1998 EPA-NCEA New: 2004 IRIS	0.30	35	
1,1 Dichloroethene	Old: 2001 IRIS New: 2004 IRIS	32	200	
Hexachlorocyclopentadiene	Old: 1997 EPA540/R-97-036 New: 2004 IRIS	0.070	0.20	
Methylene Chloride	Old: 1997 EPA540/R-97-036 New: 2004 IRIS	3000	210	
Tetrachloroethene	Old: 1998 EPA-NCEA New: 2004 IRIS	600	35	

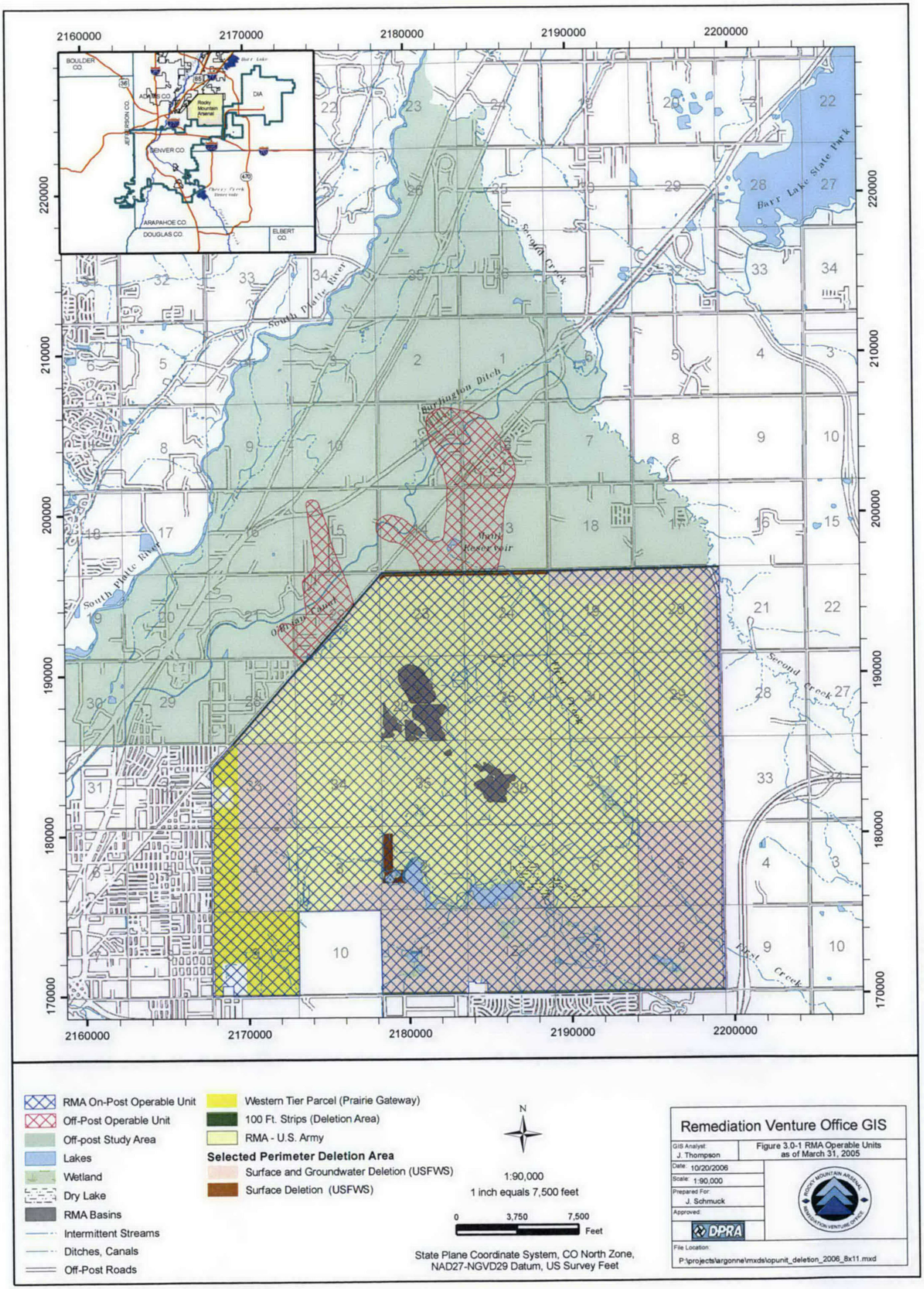
Table 8.0-1 Issues Identified and Effects on Current or Future Protectiveness

Issue	Currently Affects Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
Basin F Wastepile	N	N
Monitoring Well Maintenance and Security	N	N
Extraction Well and Extraction System Shut-off Criteria	N	N
Establishing Site-Specific PQLs	N	N
Bedrock Ridge Plume Capture	N	N
Shell Disposal Trenches Dewatering Goals	N	N
South Lakes Plume Management	N	N
OGITS Performance Objectives Clarification	N	N
Northern Pathway System Modification	N	N
North Plants Fuel Release	N	N
Changes in Monitoring Networks	N	N
Operation Assessment Report Schedule	N	N
SEO Well Notification Program (Off-Post Institutional Controls)	N	N

Table 9.0-1. Recommendations and Follow-Up Actions

Issue	Recommendations/Follow-Up Actions	Party Responsible	Oversight Agency	Milestone	Affects Current or Future Protectiveness?
Off-Post Monitoring Well Maintenance and Security	Continue routine inspections and maintenance of Off-Post monitoring wells	RVO	EPA	2007 LTMP	No
Extraction Well and Extraction System Shut-off criteria	Evaluate the need to revise the shut-off criteria during LTMP preparation and modify criteria as necessary.	RVO	EPA	2007 LTMP	No
Establishing Site-Specific PQLs	Develop procedure for establishing PQLs in accordance with available guidance. Evaluate need to make changes to lab procedures.	RVO	EPA	February 2007	No
Bedrock Ridge Plume Capture	Extraction well was added. Performance will be monitored by the RMA Water Team.	RVO	EPA	Ongoing	No
Shell Disposal Trenches Dewatering Goals	Re-evaluate dewatering goals after cover is in place.	RVO	EPA	After cover construction	No
OGITS Performance Objectives Clarification	The inconsistencies in the Off-Post ROD and other documents that allow for different interpretations of whether OGITS is a mass removal system or containment system will be clarified.	RVO	EPA	2007 LTMP	No
Northern Pathway System Modification	System will be modified to allow development in the area to proceed. Design goals will ensure that system effectiveness meets or exceeds that of the current design.	RVO	EPA	Fall 2006 startup	No
North Plants Fuel Release	Need to identify whether additional groundwater characterization and/or remediation is needed.	RVO	EPA	January 2008	No
Changes in Monitoring Network	The groundwater and surface water monitoring programs will be revised as necessary to meet current and future remedy needs and monitoring termination criteria will be modified as necessary.	RVO	EPA	2007 LTMP	No
OAR Schedule	The OARs will be issued within one year of the period covered by the report.	RVO	EPA	September 2006	No
SEO Well Notification Program	TCHD will provide oversight for the program to ensure that this IC is implemented according to the ROD.	TCHD/RVO	EPA	February 2006	No

FIGURES



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Barr Lake State Park
South Platte River
Second Creek
Burlington Ditch
First Creek
DENVER CO.
ADAMS CO.
JEFFERSON CO.
ARAPAHOE CO.
DOUGLAS CO.
ELBERT CO.
BOULDER CO.
DIA
Rocky Mountain Arsenal
RMA On-Post Operable Unit
Off-Post Operable Unit
Off-post Study Area
Lakes
Wetland
Dry Lake
RMA Basins
Intermittent Streams
Ditches, Canals
Off-Post Roads
Western Tier Parcel (Prairie Gateway)
100 Ft. Strips (Deletion Area)
RMA - U.S. Army
Selected Perimeter Deletion Area
Surface and Groundwater Deletion (USFWS)
Surface Deletion (USFWS)
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3,750
7,500
Feet
State Plane Coordinate System, CO North Zone,
NAD27-NGVD29 Datum, US Survey Feet
Remediation Venture Office GIS
GIS Analyst: J. Thompson
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Scale: 1:90,000
Prepared For: J. Schmuck
Approved:
DPRA
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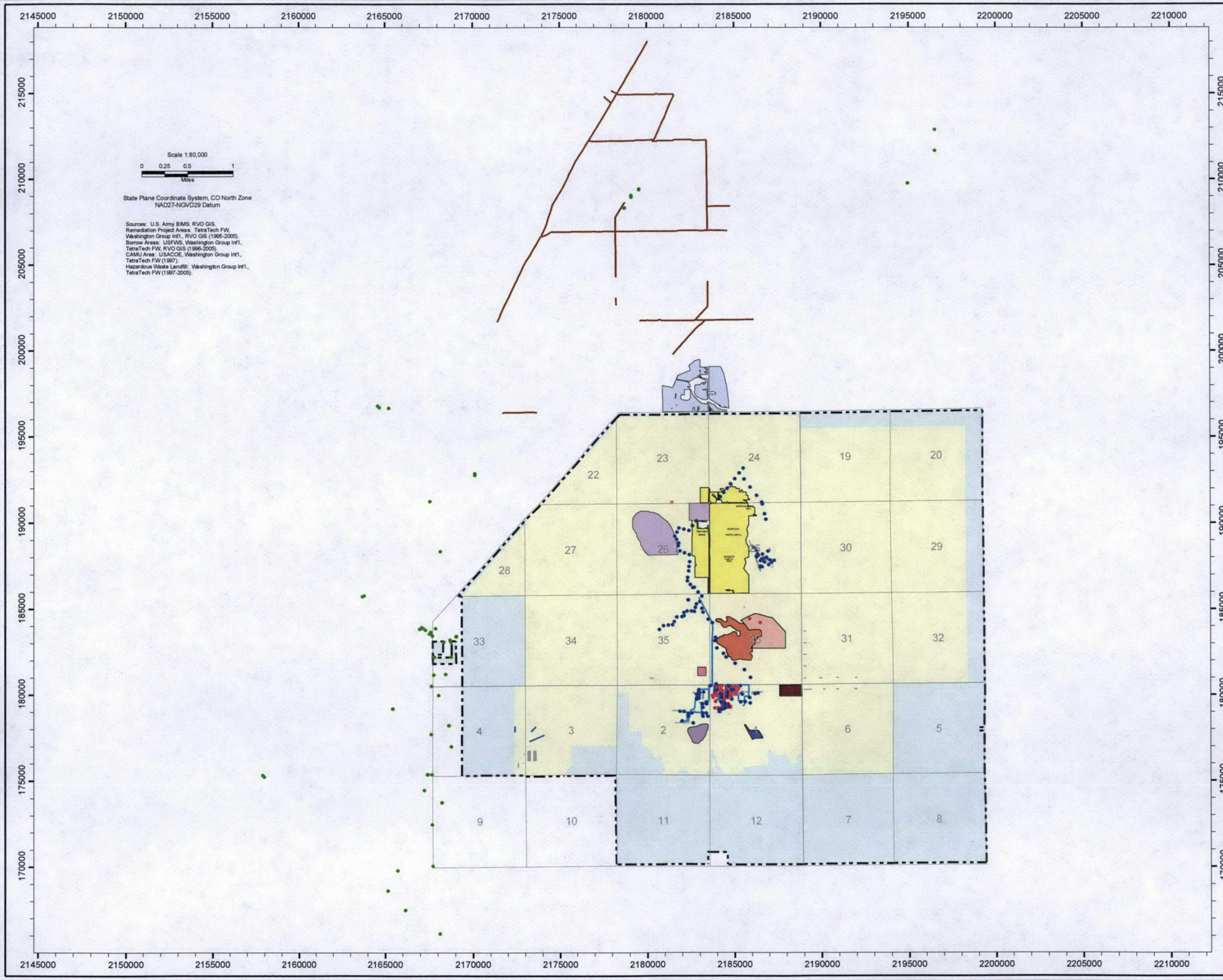
Figure 4.0-1 - Completed Projects Previously Discussed in 2000 FYRR



Legend

- South Adams County Water Supply #55
- Sanitary Sewer Manhole Plugging - Phase I #16
- Chemical Sewer Manhole Plugging - Phase I #16
- Groundwater Intercept and Treatment North of Basin F (IRA) #70
- Henderson Distribution #56
- Sanitary Sewers Remediation (IRA) #78
- Remediation of Other Contamination Sources (IRA) - Motor Pool Area Soil Vapor Extraction #80 and Groundwater Remediation #81
- CAMU Soil Remediation #2
- Basin F Liquid, Sludge, and Soil Remediation (IRA) - Element One, Basin F Wastepile #73, and Element Two, Basin F Liquid #74
- Closure of the Hydrazine Facility (IRA) #76
- Fugitive Dust Control (IRA) #77
- Remediation of Other Contamination Sources (IRA) - South Tank Farm Plume #84
- Pretreatment of CERCLA Liquid Wastes (IRA) - Wastewater Treatment System, Elements One, Two, and Three #89, #90, #91
- Off-Post Tillage Task #97
- Existing (Sanitary) Landfills Remediation - Section 1 #20

Rocky Mountain Arsenal

- U.S. Army
- USFWS
- U.S. Government Boundary
- Section Lines

Not Shown

CAMU/Basin A Well Abandonment #1
Post-ROD Removal Actions for Structures - Exterior Piping Chemical-Related Activities #18
NDMA Monitoring and Assessment #63
Closure of Abandoned Wells at RMA (IRA) #71
Building 1727 Sump Liquid (IRA) #75
Pretreatment of CERCLA Liquid Wastes (IRA) - Element Two, Polychlorinated Biphenyls (PCBs) #90
Deep Disposal Well Closure (IRA) #93
Off-Post Well Abandonment #95

Remediation Venture Office GIS

GIS Analyst: S. Cutler	RMA Remediation Areas
Date: 10/25/06	
Scale:	
Prepared For: RVO - PMC - Regulators	
Approved:	
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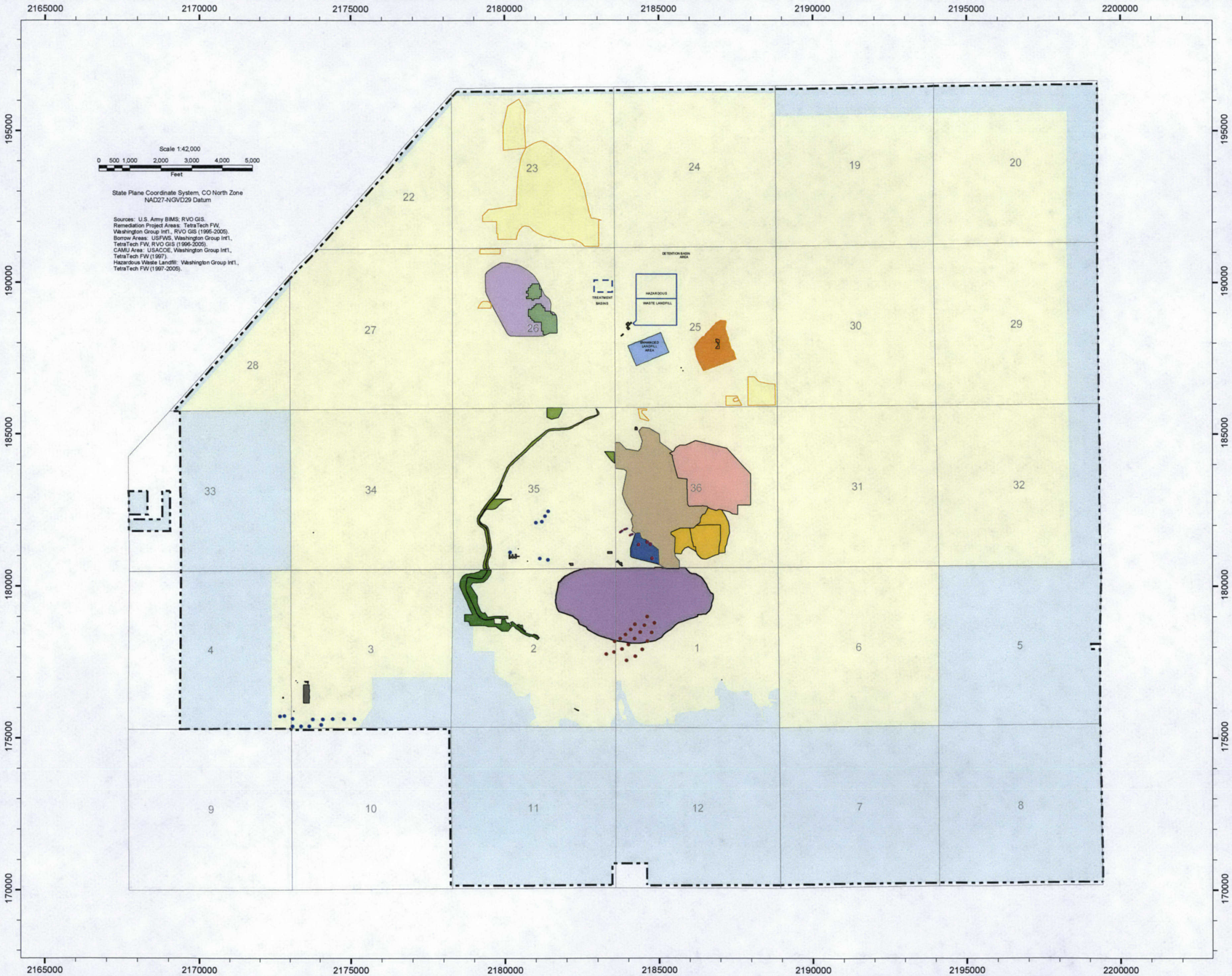
Figure 4.0-2 - Remedy Projects Not Yet Begun as of March 31, 2005



Legend

- Operations/Treatment of South Tank Farm Mass Removal System #60
- Operations/Treatment of Lime Basins Mass Removal System - Extraction Wells #60
- Sanitary Sewer Manhole Plugging Project - Phase II #35
- Lime Basins Mass Removal System - Recharge Trenches #60
- Miscellaneous RMA Structures Demolition and Removal Phase 3 #30
- Landfill Wastewater Treatment Unit (ELF Ion Exchange) #9
- Closure (cover construction) of Hazardous Waste Landfill - Cells 1 and 2 #8
- North Plants Soil Remediation #40
- North Plants Soil Remediation Free Product Removal #40
- Shell Disposal Trenches Remediation Cover Parts 1 and 2 #39
- Complex (Army) Disposal TrenchesRemediation - Subgrade Construction and Cover Parts 1 and 2 #38
- South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2, Part 3 Cover Construction #34
- Closure of Basin A Consolidation and Remediation - Cover Construction Phase 1and Notch Operations/Cover Placement #15
- Operation and Closure of Enhanced Hazardous Waste Landfill - (Cover) #12, #13
- Miscellaneous Southern Tier Soil Remediation -Sand Creek Lateral Addendum #27
- Section 35 Soil Remediation - Sand Creek Lateral Addendum #41
- Section 36 Lime Basins #47
- Former Basin F Principal Threat Soil Remediation #44
- Basin F and Basin F Exterior Remediation Phase II - Cover #46
- Residual Ecological Risk Soil Remediation, Section 6.3.3

Rocky Mountain Arsenal

- U.S. Army
- USFWS National Wildlife Refuge
- U.S. Government Boundary
- Section Lines

Remediation Venture Office GIS

GIS Analyst: S. Cutler	RMA Remediation Areas
Date: 10/25/06	
Scale:	
Prepared For: RVO - PMC - Regulators	
Approved:	

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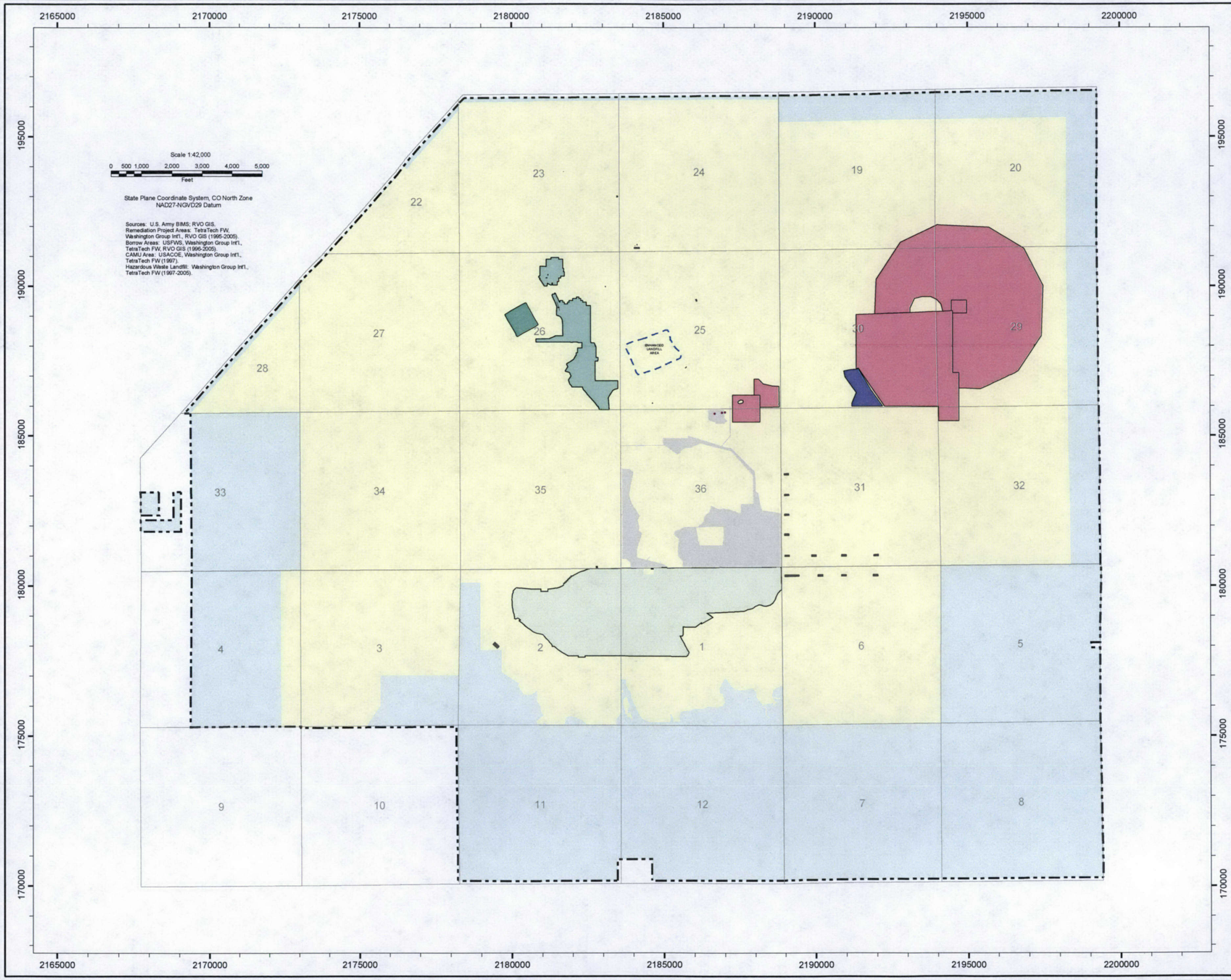
Figure 4.0-3 - Remedy Projects Under Construction as of March 31, 2005



Legend

- Section 36 Bedrock Ridge Groundwater Plume Extraction System #28
- Miscellaneous RMA Structures Demolition and Removal Phase II #30
- Construct Enhanced Hazardous Waste Landfill #11
- Basin F and Basin F Exterior Remediation Phase I #45
- South Plants Balance of Areas and Central Processing Area Soil Remediation Phase II, Part 1 and 2 #34
- Existing (Sanitary) Landfills Remediation Section 30 #22
- Munitions (Testing) Soil Remediation Part II #25
- Section 36 Balance of Areas Soil Remediation #36
- Basin F Wastepile Remediation #43

Rocky Mountain Arsenal

- U.S. Army
- USFWS National Wildlife Refuge
- U.S. Government Boundary

Remediation Venture Office GIS	
GIS Analyst: S. Cutler	RMA Remediation Areas
Date: 10/25/06	
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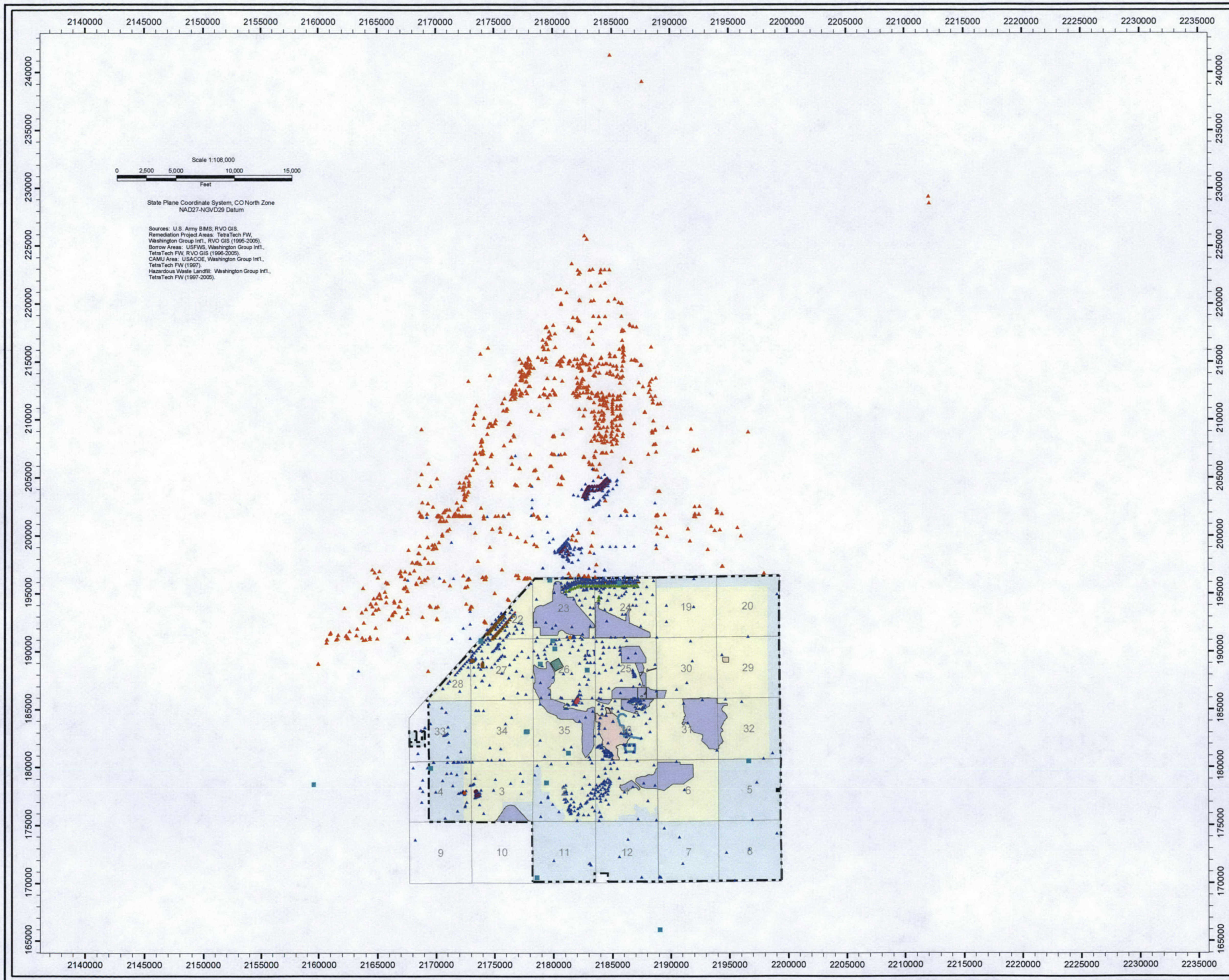

Figure 4.0-4 - Operating Remedy Projects as of March 31, 2005

Legend

- Private Well Network #96
- Operation of OGITS - Wells #94
- Site-Wide Air Monitoring #49
- Northwest Boundary Containment System - Achieve Shutdown Criteria #61
- North Boundary Containment System - Achieve Shutdown Criteria #62
- Basin A Neck Containment System - Achieve Shutdown Criteria - Wells #59
- Irondale Containment System - Motor Pool Area Treatment Shutdown #58
- Irondale Containment System - Rail Classification Yard Treatment Shutdown #58
- North of Basin F Groundwater Plume Remediation #59
- Site-Wide Groundwater Monitoring #50
- Operation of OGITS - Trenches #94
- Northwest Boundary Containment System - Achieve Shutdown Criteria - Recharge Trenches #61
- North Boundary Containment System - Achieve Shutdown Criteria - Recharge Trenches #62
- Basin A Neck Containment System - Achieve Shutdown Criteria - Trenches #59
- Complex (Army) Disposal Trenches Slurry Wall Operation #17
- Shell Disposal Trenches Slurry Wall Operation #17
- Operation of Hazardous Waste Landfill Wastewater Treatment Unit #10
- Operation of Hazardous Waste Landfill - Cells 1 & 2 #7
- UXO Management #51
- Borrow Area Operations #47a
- Operation of Basin A Consolidation and Remediation Area #14
- Basin F Waste Pile Operations and Management #65

Rocky Mountain Arsenal

- U.S. Army
- USFWS National Wildlife Refuge
- U.S. Government Boundary
- Section Lines

Not Shown

Site-Wide Biota Monitoring #48
Medical Monitoring Program #52
Operation of CERCLA Wastewater Treatment Facility #60
Off-Post Institutional Controls #98

Remediation Venture Office GIS

GIS Analyst: S. Cutler
RMA Remediation Areas
Date: 10/25/06
Scale:
Prepared For: RVO - PMC - Regulators
Approved:
DPRA
ROCKY MOUNTAIN ARSENAL REMEDIATION VENTURE OFFICE
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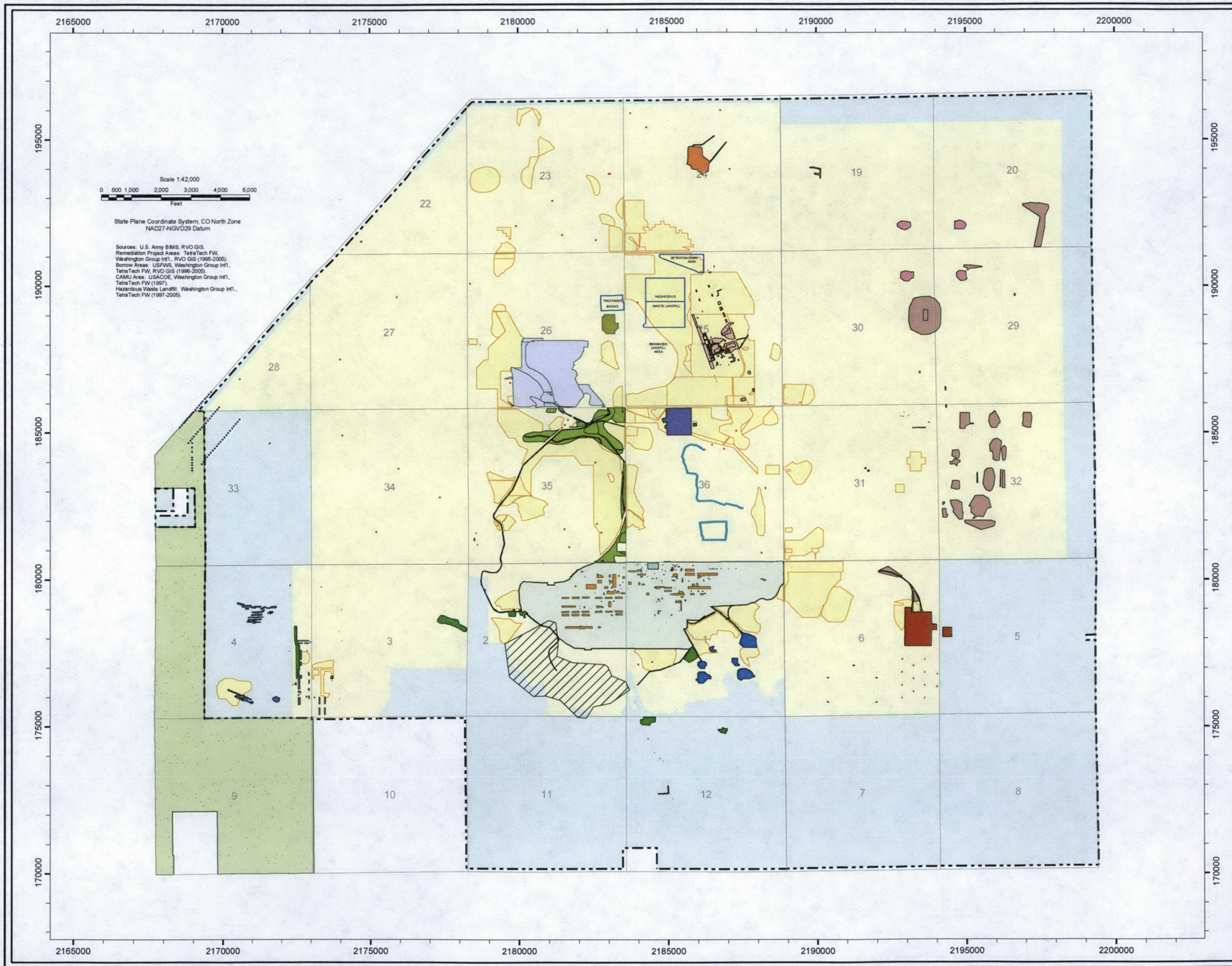

Figure 4.0-5 - Remedy Projects Completed as of March 31, 2005

Legend

- Irondale Containment System - Main Wellfield Treatment Shutdown #58
- Confined Flow System Well Closures #57
- Complex (Army) Disposal Trenches Slurry Wall (Construction) #17
- Shell Disposal Trenches Slurry Wall (Construction) #17
- South Lakes Plume Monitoring/Lake Levels #64
- Construct Hazardous Waste Landfill Cell 1 (#4) and 2 (#6), Associated Influent/Effluent Basins (#3), and Uncontaminated Detention Basin
- Section 26 HHE and Biota Exceedance Soils #5
- North Plants Structure Demolition and Removal #42
- Secondary Basins Soil Remediation Phase I and II #37
- Hex Pit Soil Remediation #32
- Buried M-1 Pits Soil Remediation #31
- South Plants Structures Demolition and Removal Phase 1 and 2 #29
- Miscellaneous RMA Structures Demolition and Removal Phase 1 #30
- Miscellaneous Northern Tier Soil Remediation #26
- Miscellaneous Southern Tier Soil Remediation #27
- Munitions (Testing) Soil Remediation Part I #25
- Burial Trenches Soil Remediation Part I and II #24
- Lake Sediments Remediation #23
- Existing (Sanitary) Landfills Remediation - Section 1 Addendum #20, Section 4 #21, Section 36 #22
- Toxic Storage Yards Soil Remediation #19
- South Plants Balance of Areas and Central Processing Area Soil Remediation Phase I #33
- Section 35 Soil Remediation #41
- Western Tier Parcel (Deletion) #53
- Residual Ecological Risk Soil Remediation, Section 6.3.3

Rocky Mountain Arsenal

- U.S. Army
- USFWS National Wildlife Refuge
- U.S. Government Boundary
- Section Lines

Not Shown

- CAMU Soil Remediation Completion and Support Project #2
- Post-ROD Removal Actions for Structures - Asbestos IRA #18
- Post-ROD Removal Actions for Structures - Interior Building Chemical Related Activities #18
- Trust Fund #54

Remediation Venture Office GIS

GIS Analyst: S. Cutler

RMA Remediation Areas

Date: 10/25/06

Scale:

Prepared For: RVO - PMC - Regulators

Approved:

DPRA

ROCKY MOUNTAIN ARSENAL REMEDIATION VENTURE OFFICE

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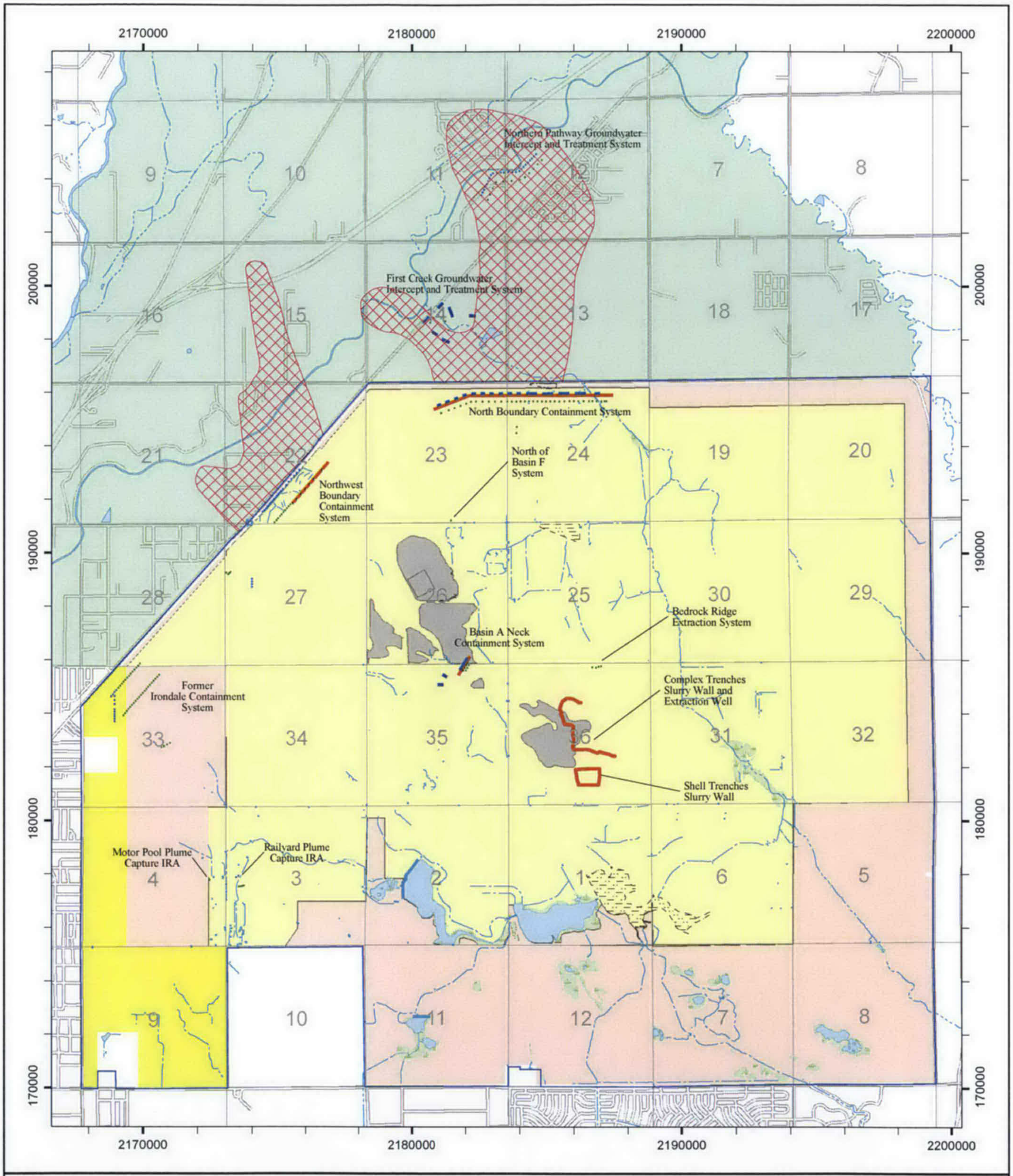


RMA On-Post Operable Unit
Off-Post Operable Unit
RMA - U.S. Army
USFWS National Wildlife Refuge
Off-post Study Area
Lakes
Wetland
Dry Lake
RMA Basins
Western Tier Parcel (Prairie Gateway)
Intermittent Streams
Ditches, Canals
Off-Post Roads
Slurry Walls
Recharge Trenches
Dewatering Wells
Recharge Wells

N

1:60,000
1 inch equals 5,000 feet

0 2,500 5,000 Feet

State Plane Coordinate System, CO North Zone, NAD27-NGVD29 Datum, US Survey Feet

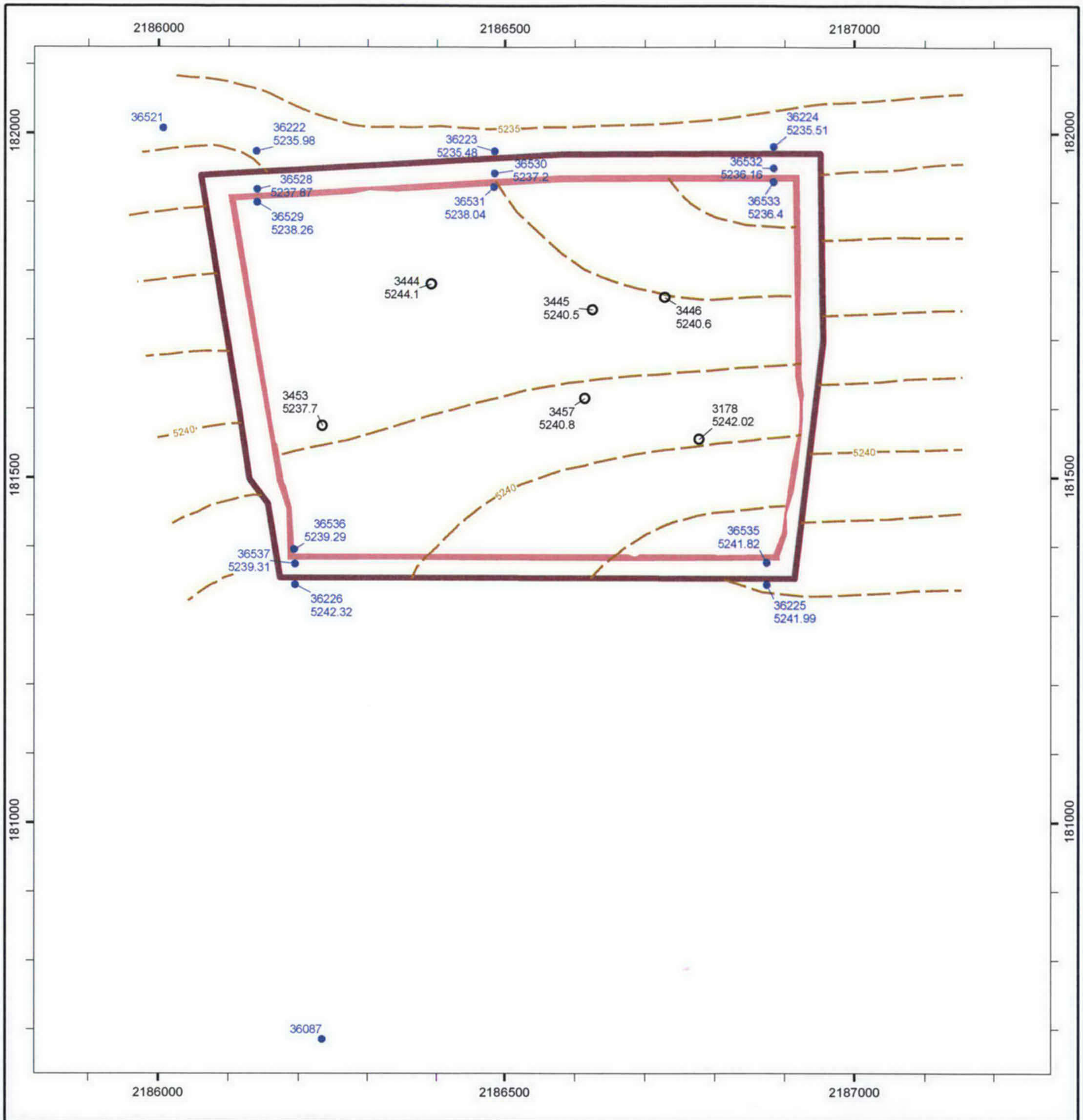
Remediation Venture Office GIS

GIS Analyst: J. Thompson
Date: 10/19/2006
Scale: 1:60,000
Prepared For: J. Schmuck
Approved:

Figure 4.1.2-1 Groundwater Systems as of March 31, 2005

DPRA

File Location: P:\projects\argonne\mxds\bnd_systems_2006_8x11.mxd



Shell Trenches Groundwater Elevations

Figure 4.1.2.1-1

Legend

- Monitoring Wells With Site ID And Water Elevation In Feet
- Boreholes With Site ID And Trench Bottom Elevation In Feet
- Groundwater Contours - Water elevations taken September 15, 2005
- Rod Slurry Wall
- IRA Slurry Wall

N

0 100 200

Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army BIMS, Washington Group, Tetra Tech, RVO GIS

Remediation Venture Office GIS

2/28/2007 DPRA, Inc. M:\projects\sitereview_00_04\mxds\shell_trenches_watelev09_05_PROFILE.mxd

Figure 4.1.2.1-2

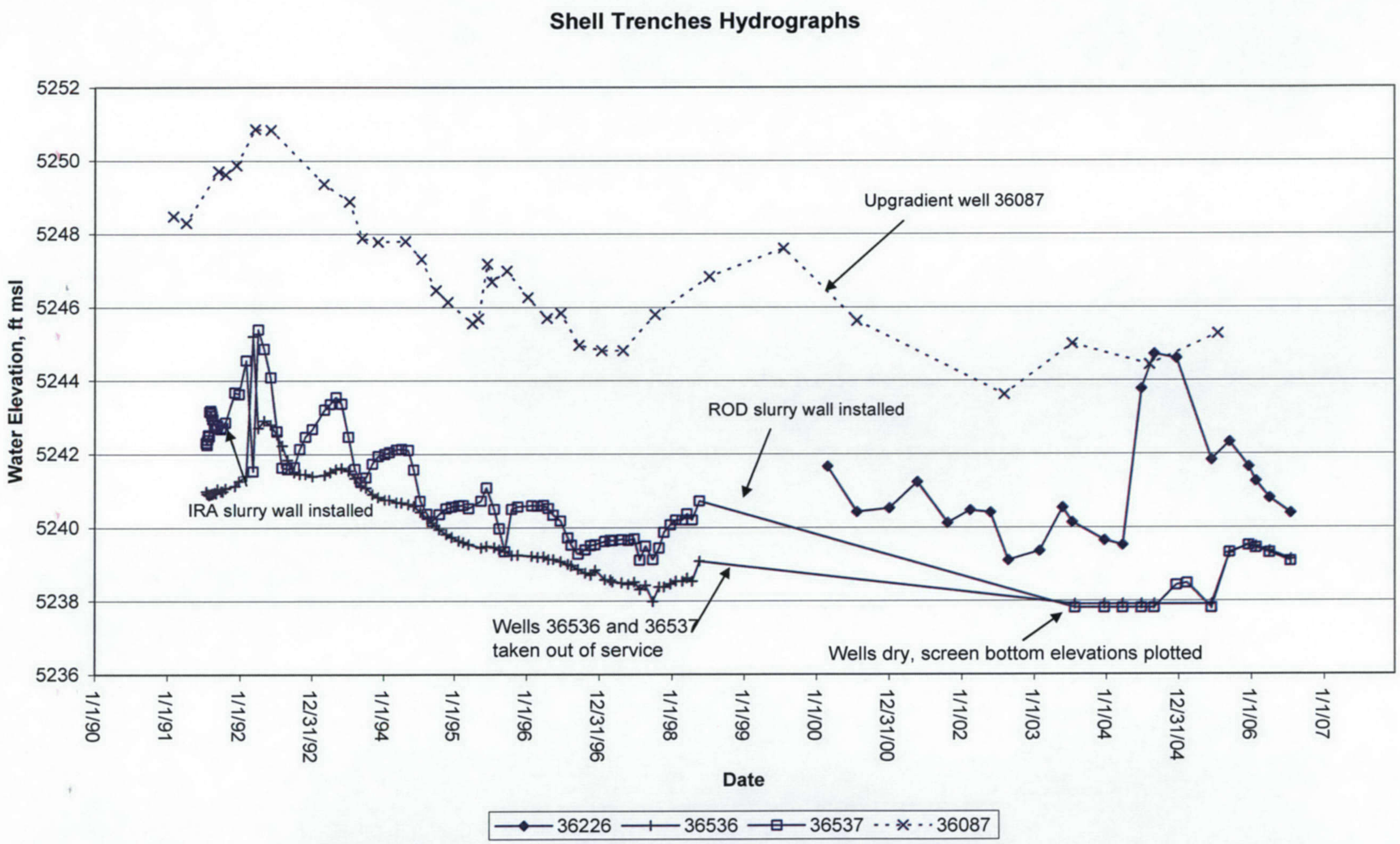
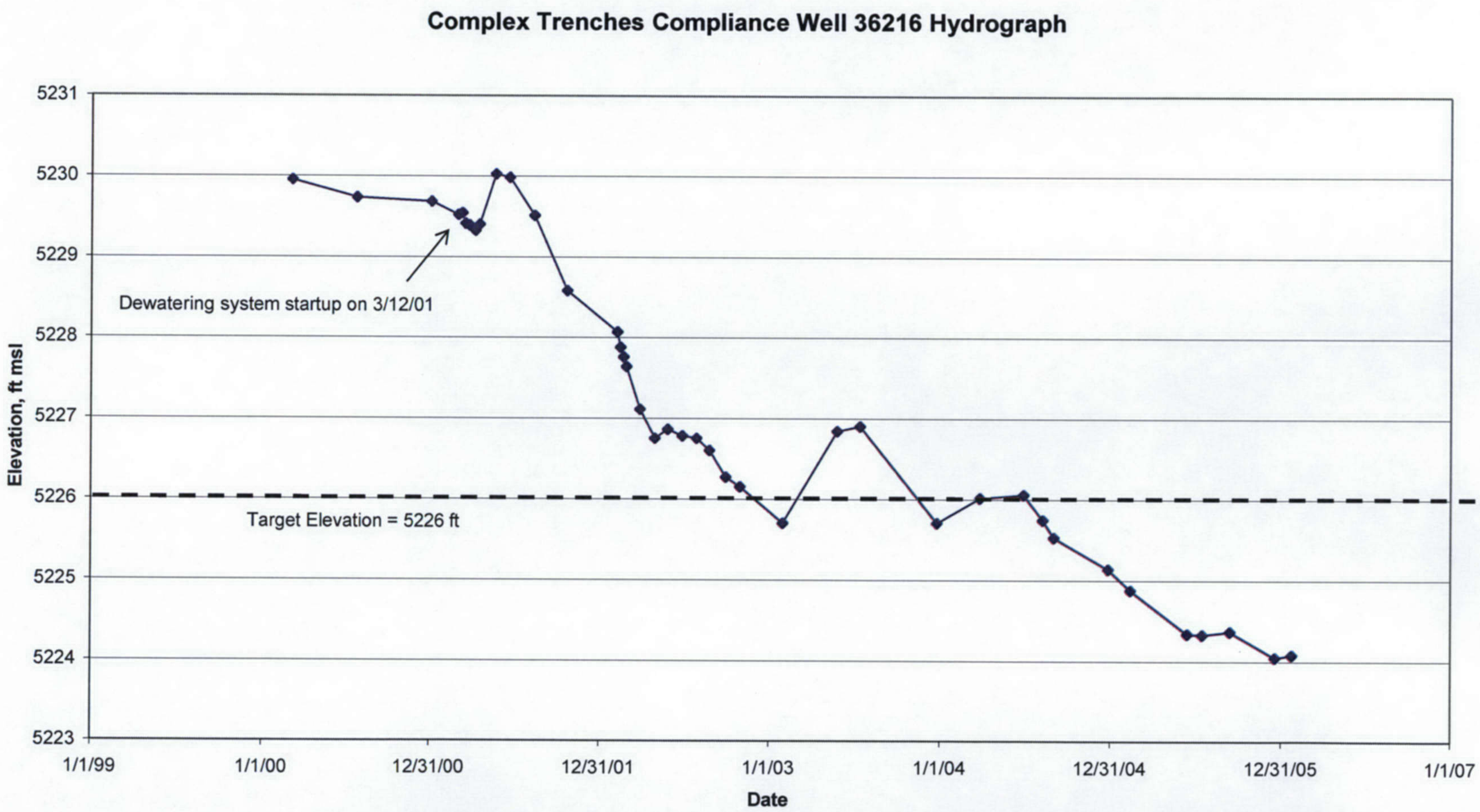


Figure 4.1.2.2-1



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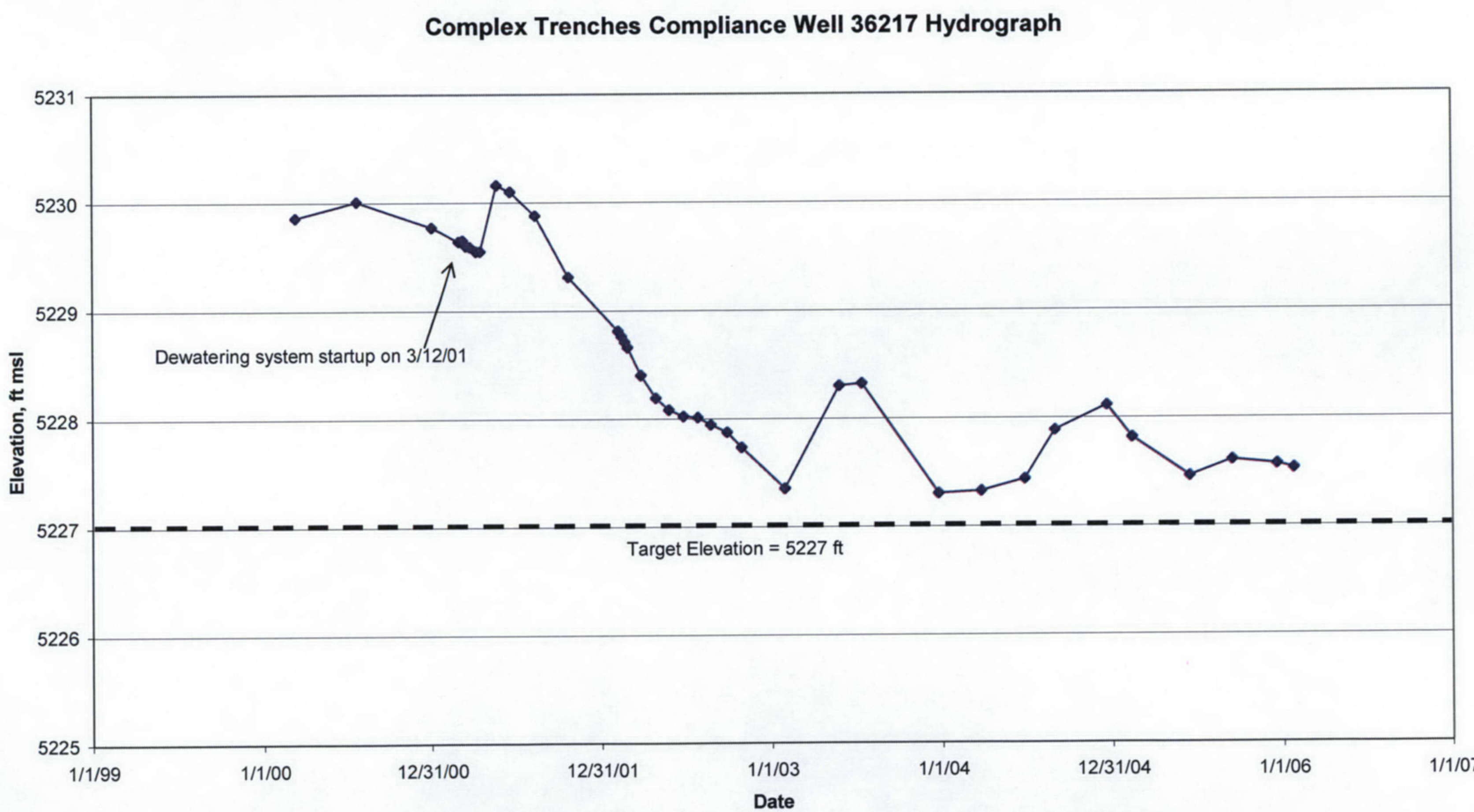

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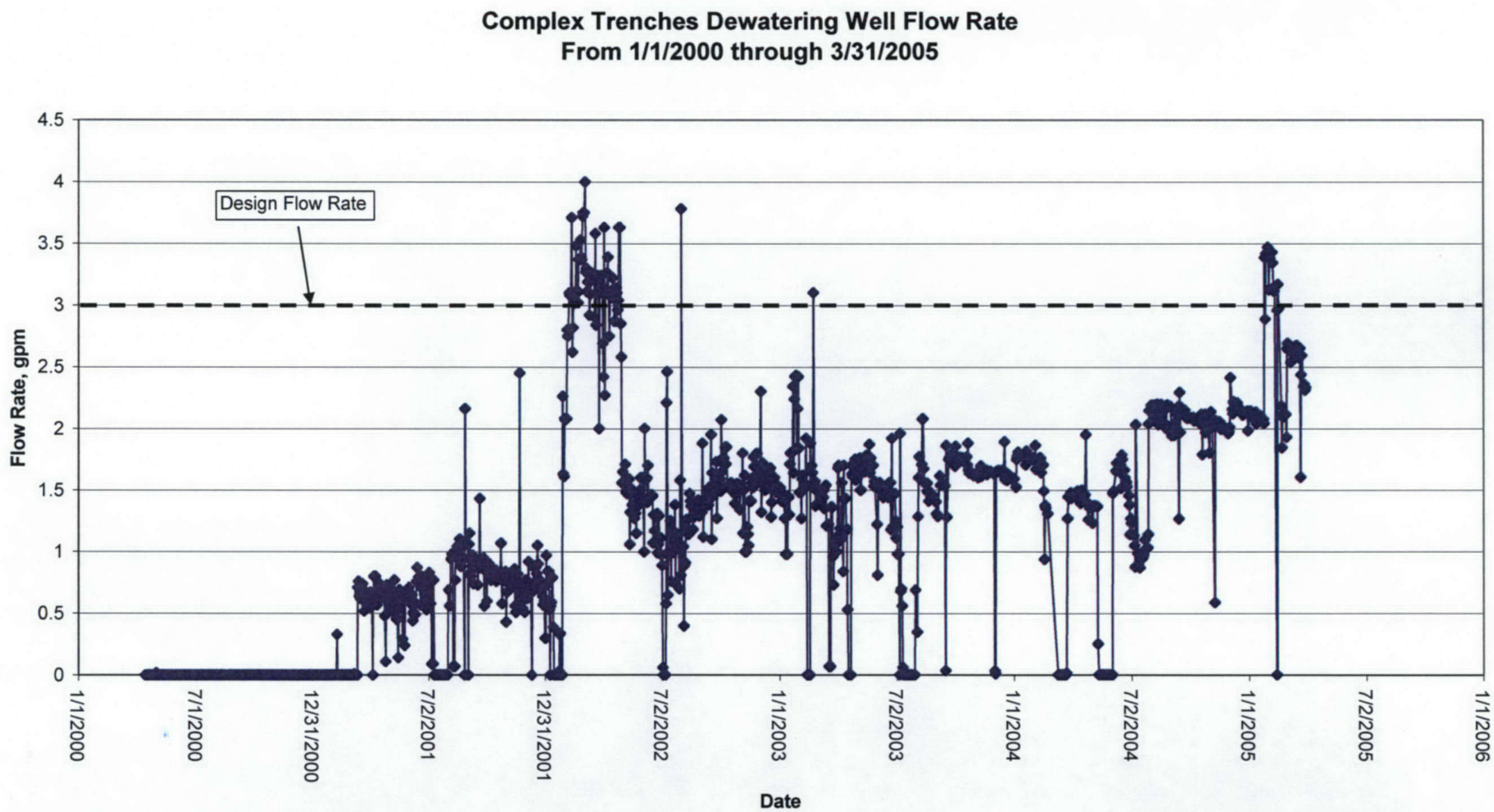
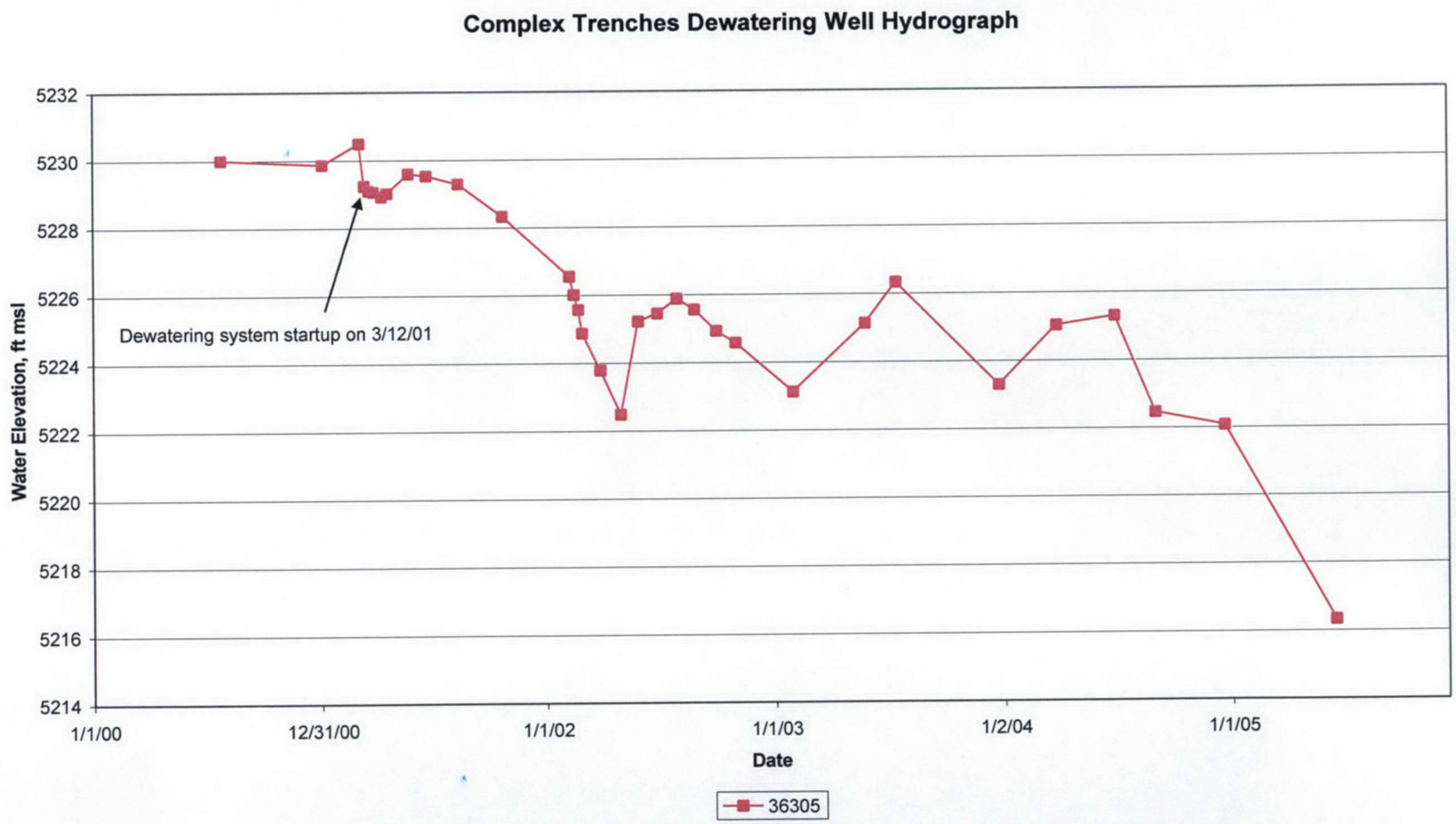
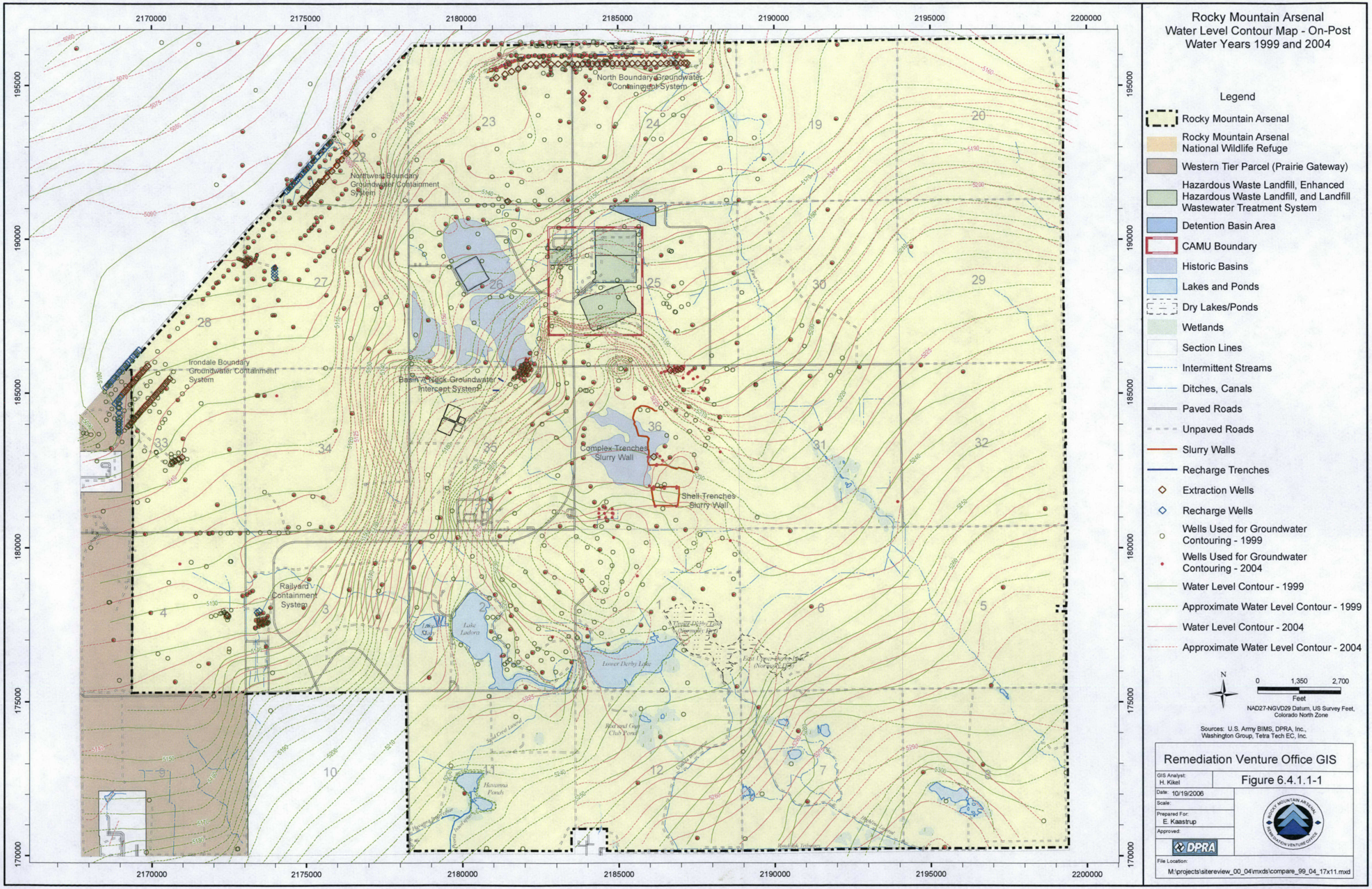
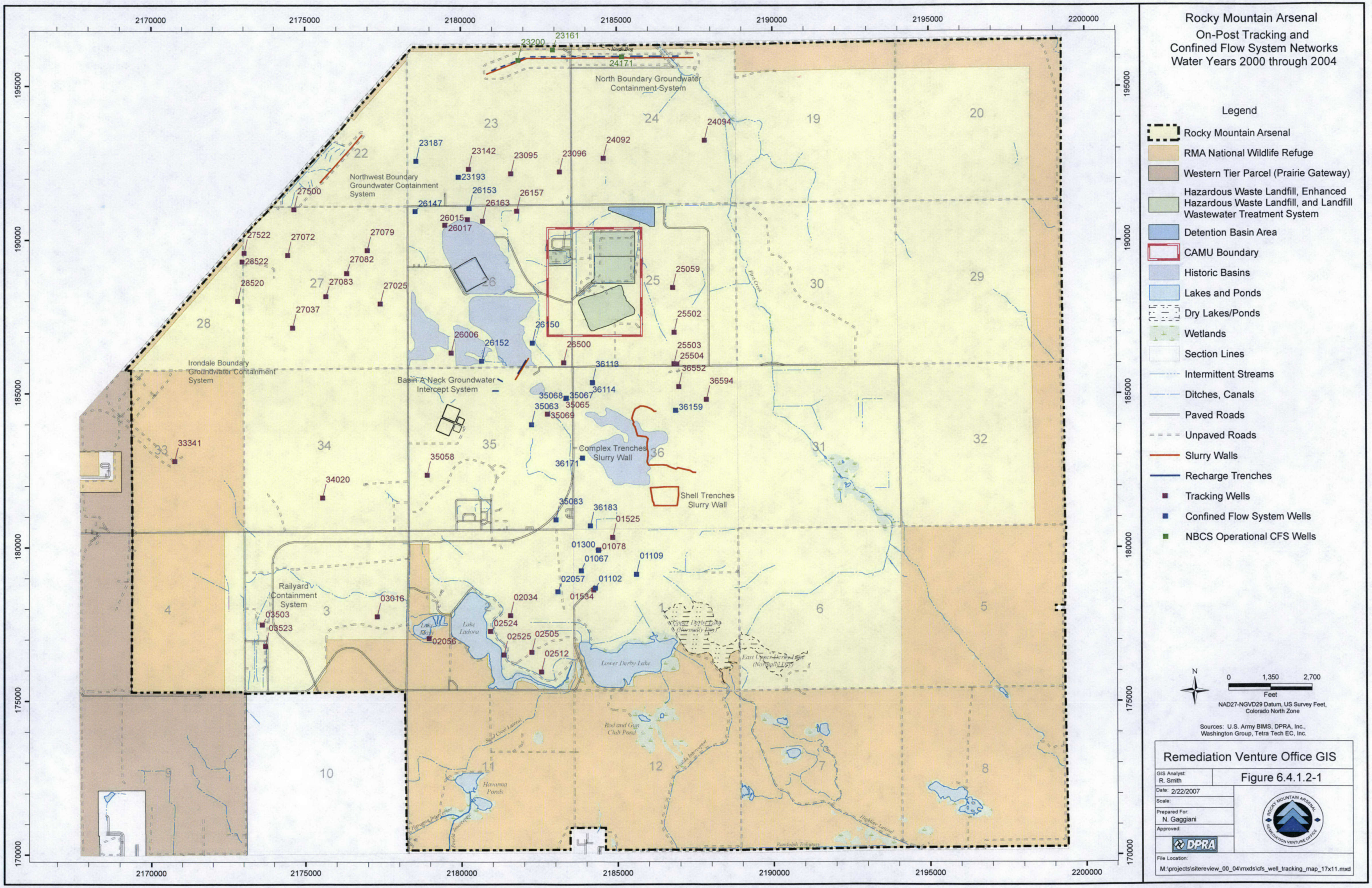


Figure 4.1.2.2-4





Rocky Mountain Arsenal
Water Level Contour Map - On-Post
Water Years 1999 and 2004
Legend
Rocky Mountain Arsenal
Rocky Mountain Arsenal National Wildlife Refuge
Western Tier Parcel (Prairie Gateway)
Hazardous Waste Landfill, Enhanced Hazardous Waste Landfill, and Landfill Wastewater Treatment System
Detention Basin Area
CAMU Boundary
Historic Basins
Lakes and Ponds
Dry Lakes/Ponds
Wetlands
Section Lines
Intermittent Streams
Ditches, Canals
Paved Roads
Unpaved Roads
Slurry Walls
Recharge Trenches
Extraction Wells
Recharge Wells
Wells Used for Groundwater Contouring - 1999
Wells Used for Groundwater Contouring - 2004
Water Level Contour - 1999
Approximate Water Level Contour - 1999
Water Level Contour - 2004
Approximate Water Level Contour - 2004
N
0 1,350 2,700
Feet
NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone
Sources: U.S. Army BIMS, DPRA, Inc., Washington Group, Tetra Tech EC, Inc.
Remediation Venture Office GIS
GIS Analyst: H. Kikel
Figure 6.4.1.1-1
Date: 10/19/2006
Scale:
Prepared For: E. Kaastrup
Approved:
DPRA
File Location: M:\projects\sitereview_00_04\mxds\compare_99_04_17x11.mxd
North Boundary Groundwater Containment System
Northwest Boundary Groundwater Containment System
Irondale Boundary Groundwater Containment System
Basin A Neck Groundwater Intercept System
Complex Trenches Slurry Wall
Shell Trenches Slurry Wall
Railyard Containment System
Lake Ladora
Lower Derby Lake
Havana Ponds
2170000
2175000
2180000
2185000
2190000
2195000
2200000
195000
190000
185000
180000
175000
170000



Rocky Mountain Arsenal
On-Post Tracking and
Confined Flow System Networks
Water Years 2000 through 2004
Legend
Rocky Mountain Arsenal
RMA National Wildlife Refuge
Western Tier Parcel (Prairie Gateway)
Hazardous Waste Landfill, Enhanced Hazardous Waste Landfill, and Landfill Wastewater Treatment System
Detention Basin Area
CAMU Boundary
Historic Basins
Lakes and Ponds
Dry Lakes/Ponds
Wetlands
Section Lines
Intermittent Streams
Ditches, Canals
Paved Roads
Unpaved Roads
Slurry Walls
Recharge Trenches
Tracking Wells
Confined Flow System Wells
NBCS Operational CFS Wells
0 1,350 2,700
Feet
NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone
Sources: U.S. Army BIMS, DPRA, Inc., Washington Group, Tetra Tech EC, Inc.
Remediation Venture Office GIS
GIS Analyst: R. Smith
Figure 6.4.1.2-1
Date: 2/22/2007
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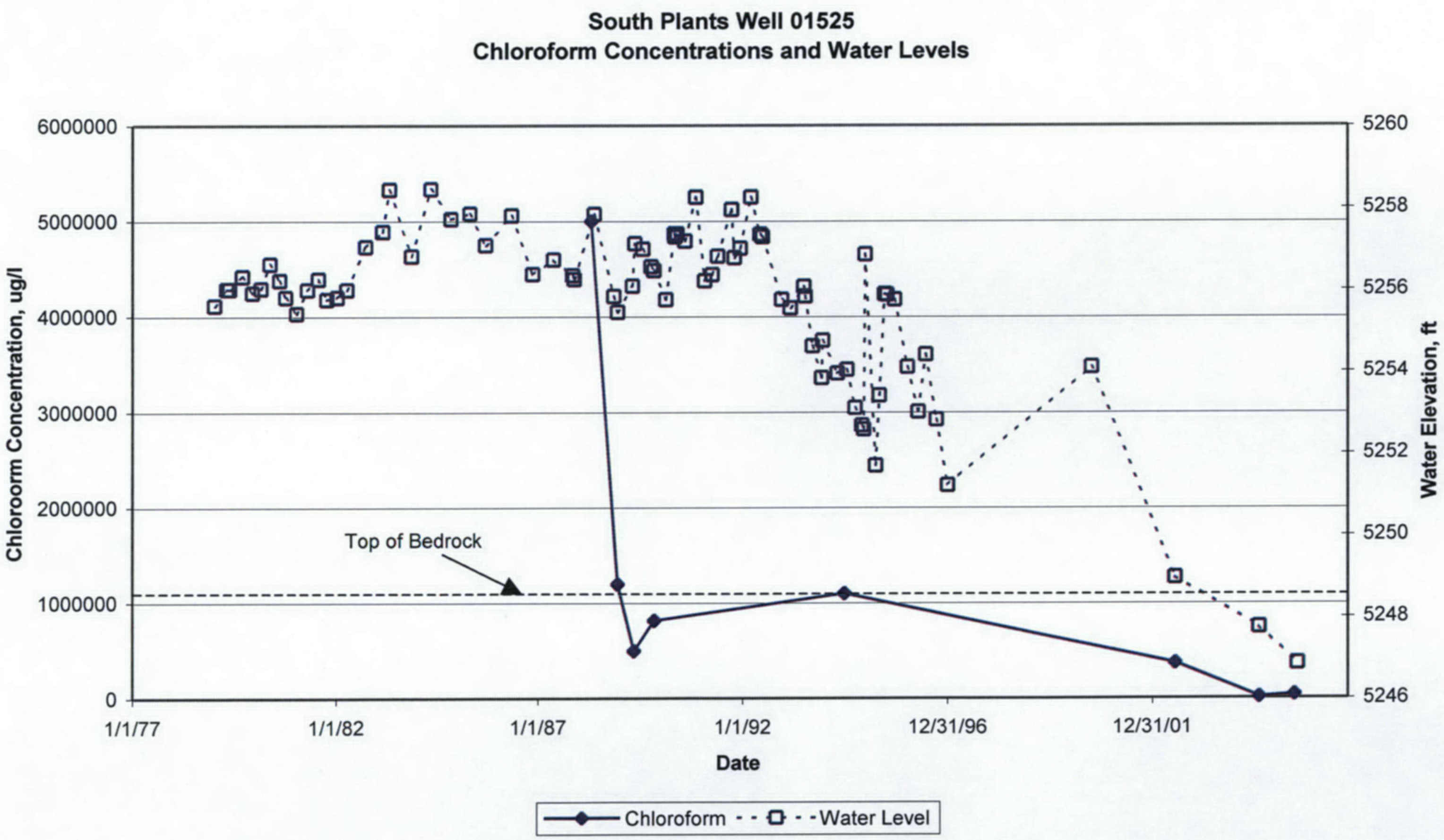
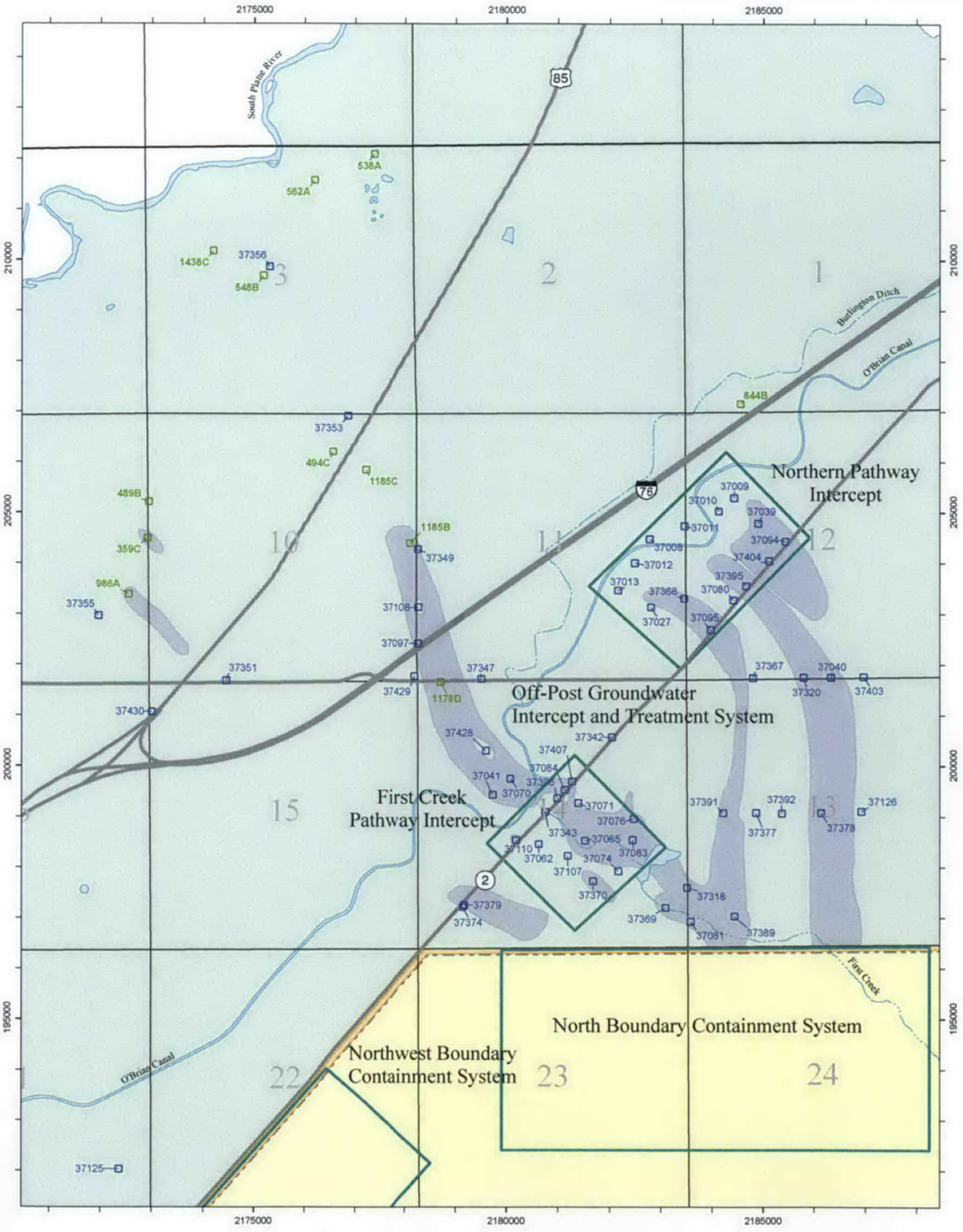
Prepared For: N. Gaggiani
Approved:
DPRA
File Location: M:\projects\sitereview_00_04\mxds\cfs_well_tracking_map_17x11.mxd
North Boundary Groundwater Containment System
Northwest Boundary Groundwater Containment System
Irondale Boundary Groundwater Containment System
Basin A Neck Groundwater Intercept System
Complex Trenches Slurry Wall
Shell Trenches Slurry Wall
Railyard Containment System
Lake Ladora
Lower Derby Lake
Rod and Gun Club Pond
Havana Ponds

Figure 6.4.1.2-2





Exceedance Monitoring Wells

Figure 6.4.1.5-1

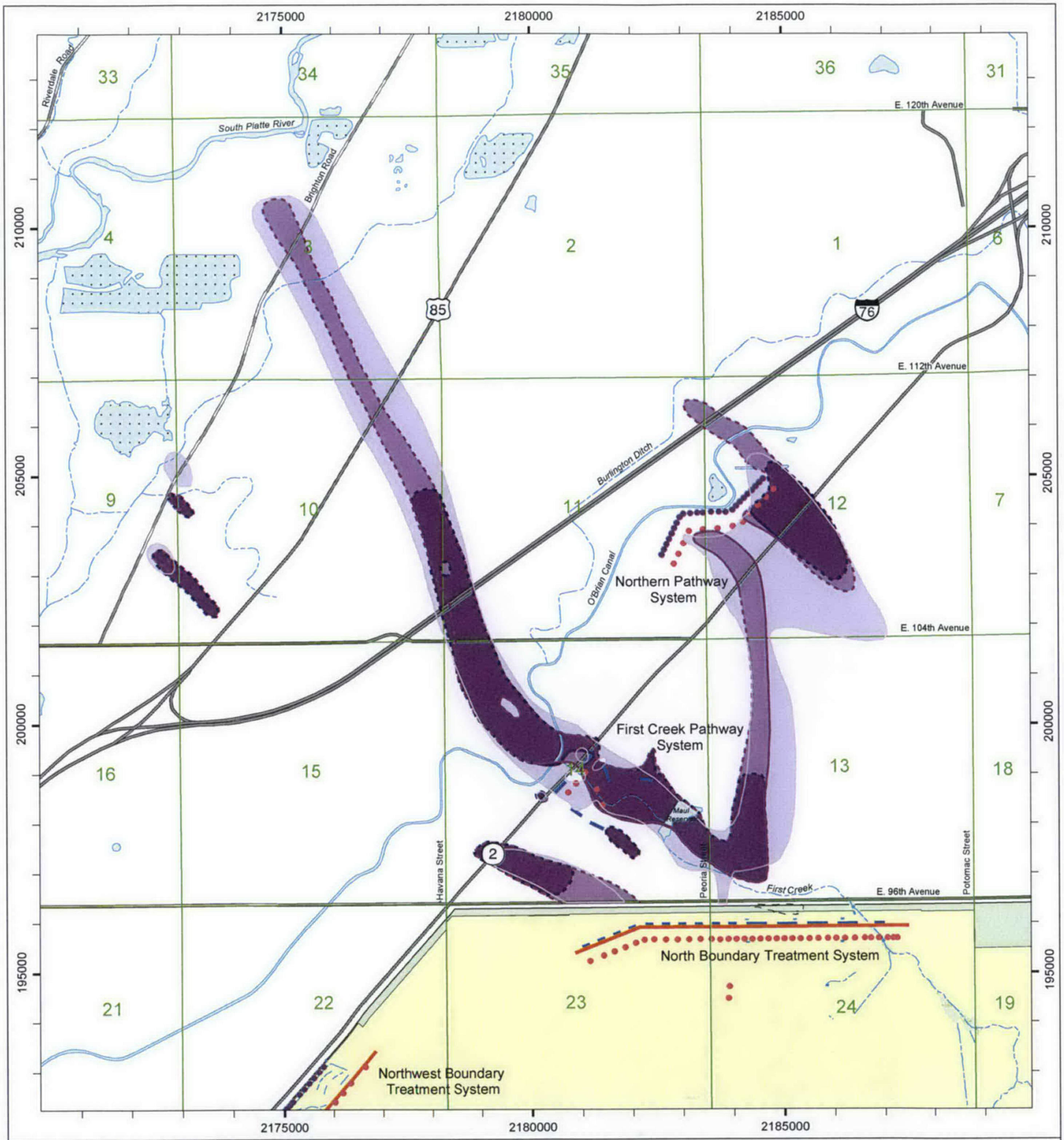
Legend

Exceedance Army Monitoring Wells	Operational Areas
Exceedance Private Monitoring Wells	Lakes, Ponds, Rivers
Primary Roads	Transfer Area
Section Lines	2004 CSRG Exceedance Areas For Organics
Township & Range Lines	Rocky Mountain Arsenal (On-Post Operable Unit)
Intermittent Streams	Off-Post Study Area
Ditches, Canals	

Remediation Venture Office GIS

Exceedance Monitoring

GIS Analyst: R. Smith
Date: 2/27/2007
Prepared For: C. Haddox
DPRA



Rocky Mountain Arsenal Off-Post DIMP Distribution 1999/2000, 2002, And 2004

Figure 6.4.1.5-2

Legend

- Rocky Mountain Arsenal
- RMA National Wildlife Refuge
- Slurry Walls
- Recharge Trenches
- Extraction Wells
- Recharge Wells

DIMP Concentrations GE 8 ug/L
(Dashed outlines where approximate)

- 2004
- 2002
- 1999 / 2000

N

0 1,325 2,650 Feet

Colorado Stateplane Coordinate System, North Zone, U.S. Survey Feet, NAD 1927

Sources: U.S. Army BIMS, Washington Group, USGS, RVO GIS

Remediation Venture Office GIS

DPRA, Inc. 2/28/2007 M:\projects\sitereview_00_04\mxds\dimp99_00_02_04_8x11.mxd

Appendix A

Public Comments Received and Responses to Comments

Appendix A

Public Comments Received and Responses to Comments

Before the initial FYR comment period (March 31 – April 29, 2005), the RVO sought public input/comments from the Site Specific Advisory Board, the Restoration Advisory Board, the USFWS Volunteers, Citizens Improvement Area Board and the Commerce City Business and Professionals Association. Although the groups asked many questions, the Site-Specific Advisory Board was the only organization to provide comments/input into the Review process. The following is a list of comments/issues gathered at the February 1, 2005 Site-Specific Advisory Board meeting:

1. List of CBSGs and a list of projects that have been completed in the last five years

2. List of upcoming remediation projects

3. Regarding the blue haze incident, what lessons learned have been incorporated into other remedy projects and how has the incident changed standard operating procedures

4. Request follow-up on how the blue haze incident affected assumptions made on the medical monitoring processes.

5. Regarding the UXO report following the Sarin bomblets discoveries, what recommendations were made and what are the plans for future projects

6. Did the RVO review the sites listed in the Summary Team Report that had the potential to find other chemical munitions and what actions were taken

7. Following the bomblet discoveries, the RVO changed its public notification process. How is that going?

8. DoD is introducing exemptions to federals for Superfund sites. How will that affect the site? Will there be financial changes? (The issues at Pueblo Depot were cited as an example.)

9. How much is the site spending on O&M?

10. Number of phone calls from the public, number of public inquiries, number of visitors to the site and the JARDF, overview of habitat restoration and number of prairie dogs at the site.

11. Regarding the water pipe that was installed a few years ago, how was public response dealt with? There was public concern about the project relating to dust and contamination. Also, there was an underlying issue with Regulatory Agency notification. The RVO did not notify regulators about the project because it was not related to the remedy, however the regulators wanted to be notified about any type of project at the site regardless whether it involved remedy or not.

12. Regarding the effectiveness of the air monitoring program, are the monitors in the correct areas (cited the example of the chloroform detection in Montbello. The group raised the possibility that the chloroform could have moved in between the two on-site air monitoring stations and was finally detected at the Montbello air station.)?

13. The off-post DIMP levels should be cleaned up vs. current approach of passive remediation.

14. Request the number of core samples taken in the 5,000 acres recently delisted

15. Review of actual delisting process

16. Relating to partial deletions, what is the change in philosophy? Originally the SSAB asked that the site be a multiple OU, but RMA became one large operable unit. Because of this decision, the SSAB was led to believe that there would not be partial deletions. The site would be deleted from the NPL after all remediation actions were completed. How do the partial deletions ensure that the cleanup has really been completed?

17. Specific review and update of long-term O&M costs as well as projected O&M costs from five years ago

18. Innovative technologies that have been tried and used at RMA.

19. Activities and phone calls that have taken place with the Rocky Mountain Poison Control Center

20. Medical Monitoring Advisory Group review

21. Dioxins review

22. Review of all the groundwater chemicals

23. Potential perchlorate contamination

Appendix B

Complex (Army) Trenches Dewatering System Evaluation of Dewatering Goals, Operational Data and Effectiveness

ROCKY MOUNTAIN ARSENAL

COMPLEX (ARMY) TRENCHES DEWATERING SYSTEM

EVALUATION OF DEWATERING GOALS, OPERATIONAL DATA, AND EFFECTIVENESS

FEBRUARY 2007

Prepared by

Rocky Mountain Arsenal
Remediation Venture Office

U.S. Department of the Army
Shell Oil Company
U.S. Fish and Wildlife Service

TABLE OF CONTENTS

List of Figures

1.0 Introduction

The following assessment is intended to provide documentation to address Regulatory Agency concerns and comments about the effectiveness of the Complex (Army) Trenches dewatering system raised during review of the RMA Draft 2005 Five-Year Review Report (FYRR), which for groundwater covers the period from FY2000 through FY2004. Data collected through June 2005 were used for this assessment to illustrate conditions that occurred at the end of the FYR period. The extended review of the FYRR also enabled the inclusion of the additional data. Concerns were expressed that the dewatering system is not operating as intended in the Record of Decision (ROD) (Foster Wheeler 1996) and Complex Trenches Design Document (RVO 1997).

The assessment of the Complex Trenches dewatering system in the Draft FYRR showed that the target water level had not yet been achieved in one of the two compliance wells and dewatering system had frequently been operated at less than the design flow rate during the 5-year review period. Flow rates were lower than the design flow rate of 3 gallons per minute (gpm) at times because of recharge capacity limitations and associated treatment concerns during much of the 5-year review period, and because of falling water levels in the dewatering trench at the end of the period. The recharge capacity was increased by installing additional recharge trenches in 2004. The treatment plant was modified in 2004 by replacing the air stripper. This modification provided an added benefit of reducing the plugging of the recharge trenches, and some of the capacity in the original trenches has been regained.

Much of the information in this document was presented to the Regulatory Agencies in a meeting held on January 23, 2007. The information presented here is provided to document the conclusion concerning the effectiveness of the Complex Trenches dewatering system, and to support the FYRR.

Following this section, the assessment is organized as follows:

- Complex Trenches Remedy and Dewatering Goals
    - ROD Goal
    - Design Document Goals
- Technical Documentation
    - Groundwater Modeling Assumptions and Results
    - Dewatering System Operational and Precipitation Data
- Performance Conclusions and Recommendations
    - Conclusions
    - Recommendations
- References

2.0 Complex Trenches Remedy and Dewatering Goals

The remedy for the Complex Trenches consists of a slurry wall to contain the alluvial groundwater within the Complex Trenches site, an alluvial dewatering system, and a RCRA-equivalent cover. The slurry wall was installed in 1999. The dewatering system, which consists of a 200-foot long dewatering trench and dewatering well located within the trench, were installed in April 2000 and began operating in March 2001. The associated monitoring wells were installed in 2000. The RCRA-equivalent cover will be installed during the next FYR period.

Figure 2-1 shows the locations of the slurry wall, dewatering trench and well (36305), compliance wells (36216 and 36217), associated monitoring wells, and the Complex Trenches site boundary. Figure 2-1 also shows that the alluvium is saturated in only the western portion of the site where the slurry wall and dewatering system are located. The dewatering system was located in proximity to the disposal trenches and is only intended to lower the water levels in that area. Where the alluvium is shown to be unsaturated in Figure 2-1, the groundwater flows within the underlying Denver Formation bedrock to the northeast and is intercepted by the Bedrock Ridge groundwater extraction system and treated and recharged at the Basin A-Neck system.

2.1 ROD Goal

The Onpost ROD stated the following dewatering goal for the Complex Trenches in ROD Table 9.5-1:

Dewater as necessary to ensure containment.

This goal was addressed by the design and installation of the dewatering trench and well.

2.2 Design Document Goals

The Complex Trenches Design Document included the dewatering goal of lowering the water table to below the elevation of the disposal trench bottoms. Two compliance wells (36216 and 36217) were installed and target water elevations were established for each well. Groundwater modeling was conducted to estimate the time to reach the target water levels under specific conditions. The groundwater modeling is discussed further in Section 3.1.

The design flow rate of 3 gpm was chosen to provide a safety factor above the modeled flow rate estimate and to design components of the system. According to accepted industry practice, the design flow rate is a conservative flow rate used for sizing system components. It is neither intended to be a minimum required operating rate nor a ROD or Design Document standard.

While an estimated timeframe for achieving the target water levels was developed, no timeframe standard for meeting the dewatering goals was established in the design. Additionally, no requirement was established that the dewatering goals must be met before the RCRA-equivalent cover is constructed. If it had, the design would have needed to address reduction of groundwater recharge (e.g., by eliminating all topographic depressions and maintaining good vegetation) prior to RCRA-equivalent cover construction.

3.0 Technical Documentation

This section includes discussions of the groundwater modeling, dewatering system operational flow rate and water level data, and precipitation data.

3.1 Groundwater Modeling Assumptions and Results

3.1.1 Modeling Objective

The Design Document stated that the modeling objective was to predict drawdown as a function of time and pumping rates.

3.1.2 Modeling Input and Assumptions

Multiple input parameters reflecting hydrogeologic conditions are utilized in groundwater modeling. For the Basin A model used in the Complex Trenches dewatering system design, some of the input values were assumed since it was not feasible to obtain measurements of all of the model inputs. For example, assumed values for specific yield, slurry wall thickness and hydraulic conductivity, and recharge were made based on the information available in 1997. The assumed recharge rates were 0.1 inch/year in vegetated areas and 0.25 inch/year in unvegetated areas. Based on water-level and precipitation data collected during the FYR period, it appears that actual recharge rates were higher than the assumed recharge rates except during the drought year of 2002. The recharge rates assumed in the model are also significantly higher than expected to occur when the RCRA-equivalent covers are constructed.

3.1.3 Modeling Results and Conclusions

The model predicted more than 3 feet of drawdown near the middle of Disposal Trench 3 (near compliance well 36216) and more than 2 feet of drawdown at the east end of Disposal Trench 5 (near compliance well 36217) after 5 years of pumping at a continuous rate of 2 gpm. Based on 1996 water levels (used as the initial conditions in the model), this amount of drawdown would have achieved the drawdown objectives. This modeling estimate was not considered, and should not now be viewed, as a standard for achieving the target water elevation in the compliance wells.

3.2 Dewatering System Operational and Precipitation Data

3.2.1 Dewatering Well Flow Rate

Figure 2-1 shows the location of the dewatering well (36305) and Figure 3-1 shows the dewatering well flow rate. The modeled and design flow rates also are indicated on Figure 3-1 for reference. From system startup in March 2001 through 2002, the pumping rate ranged from 0.7 to 4 gpm, averaging almost 1.3 gpm. The flow rate of 4 gpm occurred on one day (3/5/2002) during a period when the upper limit of the capacity was evaluated. These higher rates were not sustainable, however.

The flow rate was increased over time and averaged approximately 1.6 gpm from January 2003 through June 16, 2005. Overall during the first 4 years of operation, the flow rate averaged 1.4 gpm, which is 30% less than the 2 gpm in the model simulations.

Beginning in January 2005, the flow rate seemed to begin displaying a gradually decreasing trend. This decreasing trend is related to falling water levels in the dewatering trench, which required that the pumping rate be reduced to prevent on-and-off cycling of the pump. Figure 3-2 shows the water levels for the dewatering well and the trench piezometer, which typically track each other since the water level in the gravel–filled trench is flat (i.e., horizontal). Comparison of the water level in the trench to that in compliance well 36216 suggests that the specific capacity of the dewatering trench was decreasing in 2005. This situation will be evaluated further during the next FYR period when more data will be available.

3.2.2 Water-Level Changes in Response to Flow Rates and Precipitation

As shown on Figure 2-1, monitoring well pairs are located to the west and south of the dewatering trench. In each well pair, one well is located inside the slurry-wall enclosure and one well is located outside. These wells are monitored to determine the groundwater elevations on both sides of the slurry wall.

Since 2000, water levels outside the slurry-wall enclosure have been higher than inside. Thus, an inward hydraulic gradient across the slurry wall has occurred at monitoring-well pairs 36218/36219 and 36220/36221 (Figures 3-3 and 3-4). The head differentials increased from one foot before dewatering started to 5 or 6 feet after pumping of the dewatering system began. Even while water levels outside the slurry wall have risen, likely due to infiltration of precipitation and recharge of groundwater, water levels inside the slurry wall have declined overall.

Figures 3-5 and 3-6 show the measured water elevations in the compliance wells, the respective target water elevations, annual precipitation recorded at the nearby Stapleton weather station, and the average annual precipitation. Figure 3-6 also shows the flow rates at different times, and the average flow rate prior to and after 2003. From startup of the dewatering system in March 2001 through 2002, the pumping rate averaged about 1.3 gpm (i.e., 35% less than the 2 gpm in the model simulations). Even with the low average pumping rate, water levels fell rapidly and almost met the dewatering goals during the 2002 drought (Figures 3-5 and 3-6), indicating that when recharge is minimal (as will be the case when RCRA-equivalent covers are in place), dewatering goals can be reached at a low pumping rate.

From January 2003 through June 2005, the average flow rate increased to approximately 1.6 gpm, and the annual precipitation returned to near average amounts. Even with an increased average pumping, the increased precipitation and associated recharge affected the water levels. Observations for the two compliance wells are as follows:

- Compliance well 36216. The dewatering goal (i.e., the target elevation of 5226 feet) was achieved in parts of 2003 and 2004, and 2005 through the end of the FYR period (Figure 3-5).

- Compliance well 36217. With the return to normal annual precipitation (Figure 3-6) and sometimes unusually high monthly precipitation after 2002 (Figure 3-7), the downward trend in water levels stopped just before reaching the water-level goal. Since 2002, the average flow rate was higher (1.6 gpm), but the water levels have remained above the goal and fluctuated seasonally, usually within 1 foot of the goal, because of the additional recharge. Drawdown was less in well 36217 than in well 36216, as predicted by the modeling.

The maximum amount of drawdown in the compliance wells since March 2001 was 5.2 feet in well 36216 in 2005 and 2.3 feet in well 36217 in 2003, which exceeds the amount of drawdown that was estimated to be required to meet the goals in the Design Document in 1997. Since water levels prior to startup (i.e., in March 2001) were higher than the initial water levels used in the modeling (i.e., water levels in 1996), additional drawdown is still needed to meet water-table elevations goals.

4.0 Performance Conclusions and Recommendations

4.1 Conclusions

1. Since an inward hydraulic gradient has been maintained across the slurry wall, containment by the slurry wall has been achieved as required by the ROD.
2. The operational data indicate that the groundwater model provided fairly reasonable drawdown predictions from pumping.
3. The actual amount of drawdown in the compliance wells caused by pumping has exceeded that estimated to meet the goals in 1997, but since water levels in 2001 (when the system began operating) were higher than in 1997, the water-level goal in one of the two compliance wells has not yet been met.
4. Drought-year (i.e., 2002) data illustrate that with minimal recharge (such as will be the case when the RCRA-equivalent covers are in place) the dewatering goals can likely be met even with a pumping rate significantly less than the design flow rate (i.e., 3 gpm) and less than the modeled flow rate (i.e., 2 gpm).
5. Prior to cover construction, the dewatering system is performing as was expected in the Decision Documents (i.e., the ROD and Design Document).
6. Dewatering goals likely will not be met until after the RCRA-equivalent covers are installed.
7. Performance of the dewatering system should not be evaluated against the dewatering goals until after the RCRA-equivalent covers are constructed.

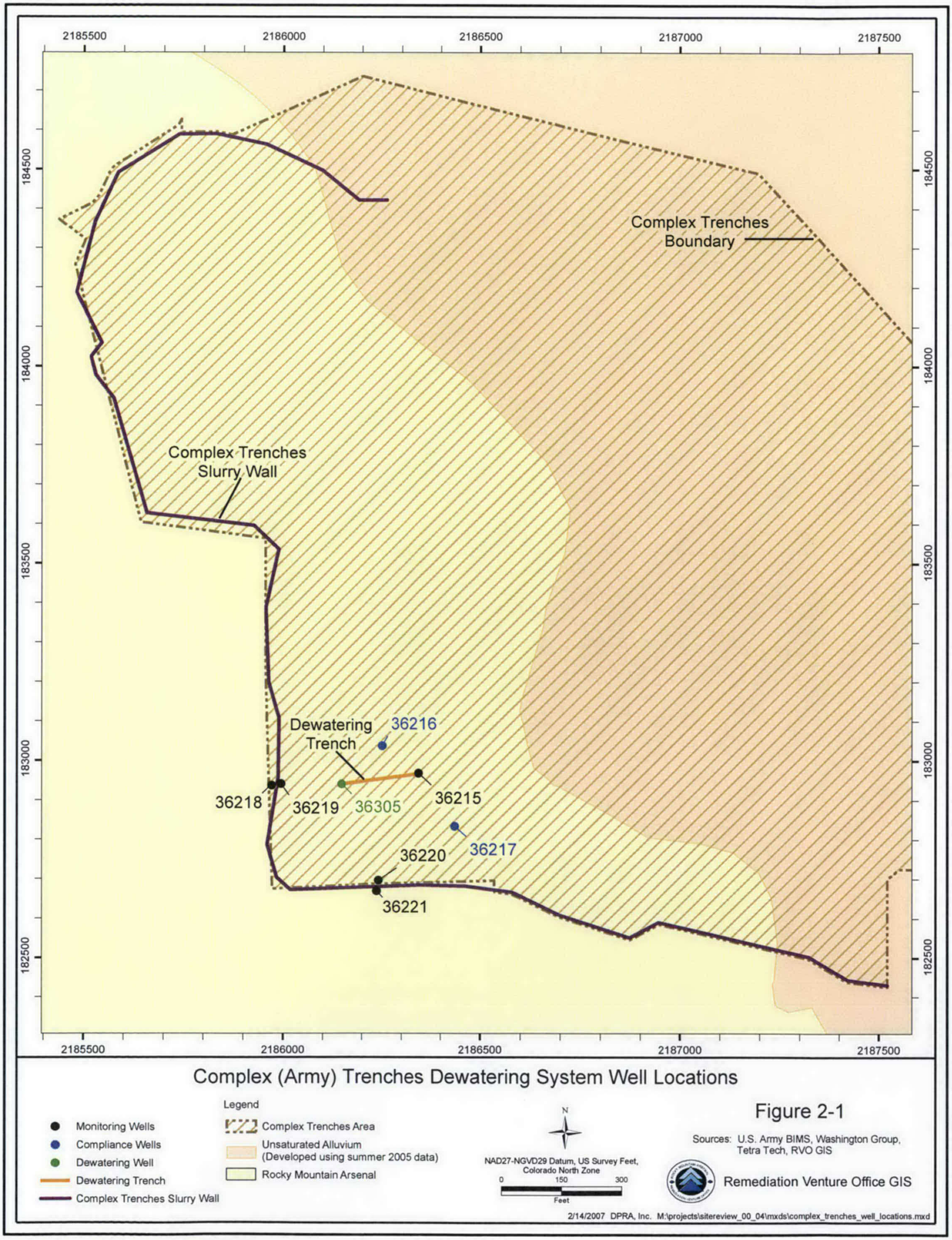
4.2 Recommendations

1. Since dewatering trench performance appeared to be declining at the end of the 5-year review period, trench performance will be evaluated in 2007.
2. Having resolved previous treatment and recharge capacity limitations, RVO will attempt to maintain a higher average pumping rate than in the previous FYR period.

5.0 References

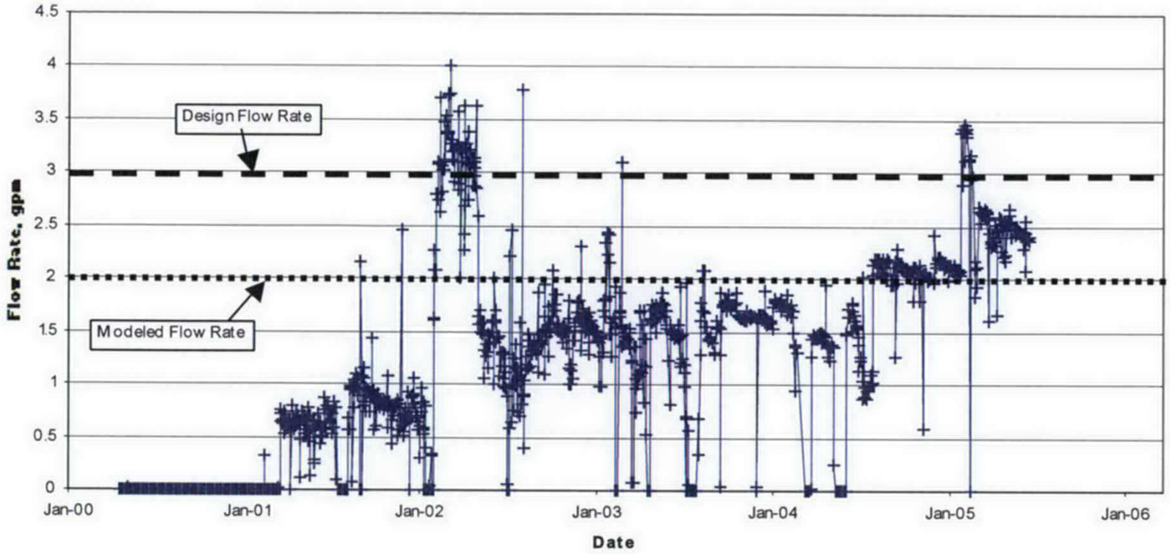
Foster Wheeler Environmental Corporation, 1996. *Record of Decision for the On-Post Operable Unit.* Volume 1. June.

Remediation Venture Office (RVO), 1997. *Complex Trenches and Shell Section 36 Trenches Groundwater Barrier Project, 100 Percent Design Package.* September.



2185500
2186000
2186500
2187000
2187500
184500
184000
183500
183000
182500
Complex Trenches Boundary
Complex Trenches Slurry Wall
Dewatering Trench
36216
36215
36218
36219
36305
36217
36220
36221
Complex (Army) Trenches Dewatering System Well Locations
Legend
Monitoring Wells
Compliance Wells
Dewatering Well
Dewatering Trench
Complex Trenches Slurry Wall
Complex Trenches Area
Unsaturated Alluvium
(Developed using summer 2005 data)
Rocky Mountain Arsenal
N
NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone
0
150
300
Feet
Figure 2-1
Sources: U.S. Army BIMS, Washington Group, Tetra Tech, RVO GIS
Remediation Venture Office GIS
2/14/2007 DPRA, Inc. M:\projects\sitereview_00_04\mxds\complex_trenches_well_locations.mxd

Figure 3-1
Complex Trenches Dewatering Well Flow Rate



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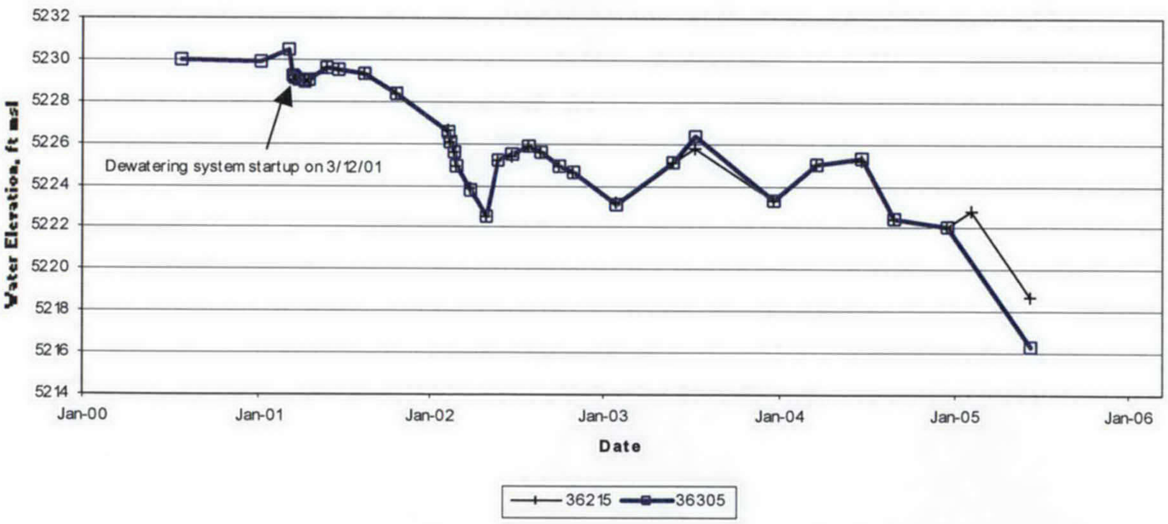

Figure 3-3
Well Pair 36218/36219 Hydrographs

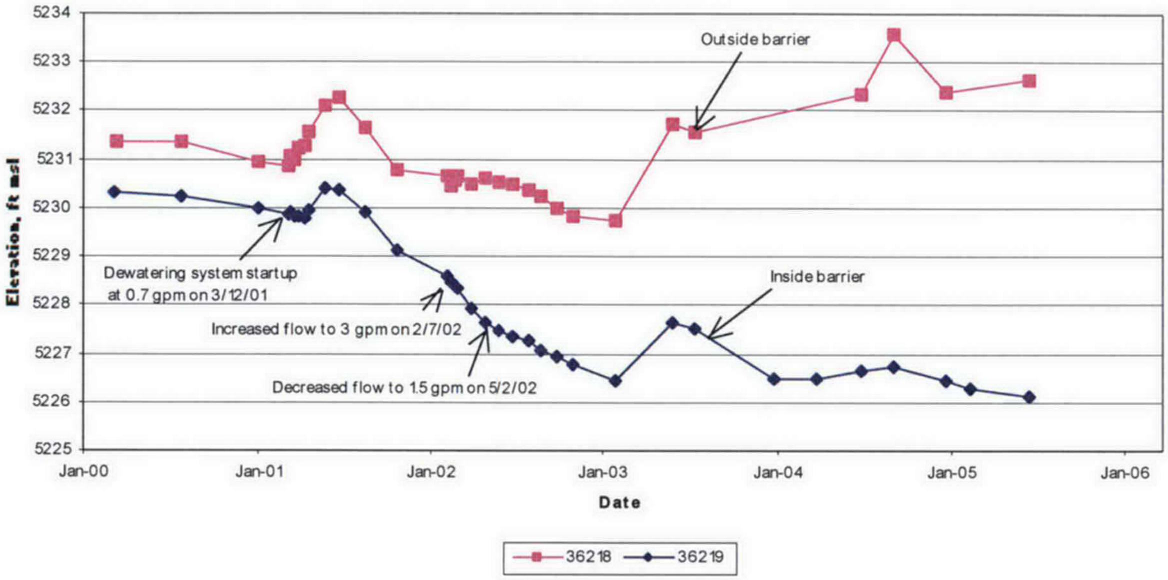

Figure 3-4
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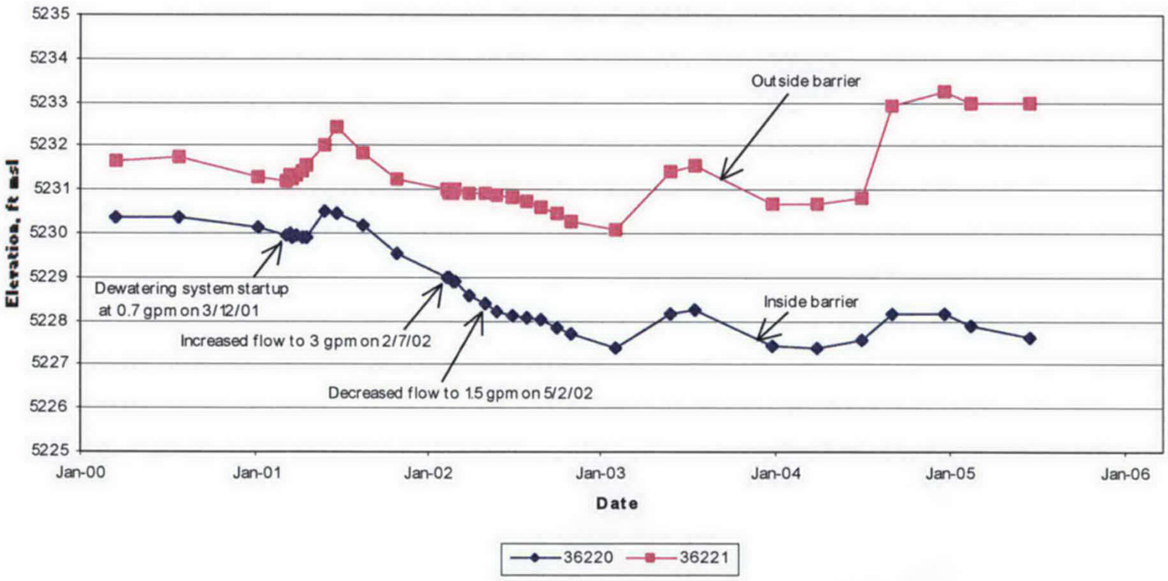


Figure 3-5
Complex Trenches Compliance Well 36216 Hydrograph and Annual Precipitation

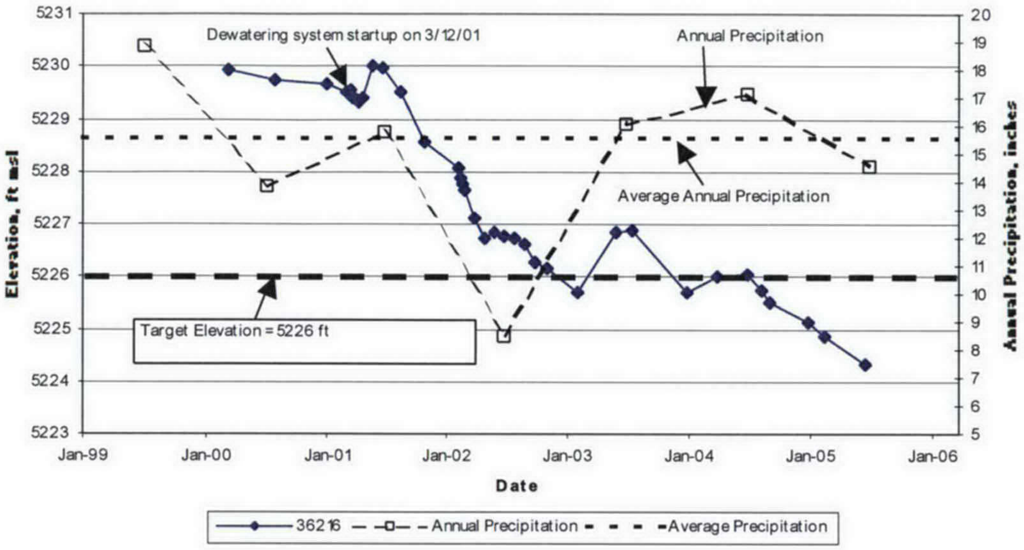


Figure 3-6
Complex Trenches Compliance Well 36217 Hydrograph and Annual Precipitation

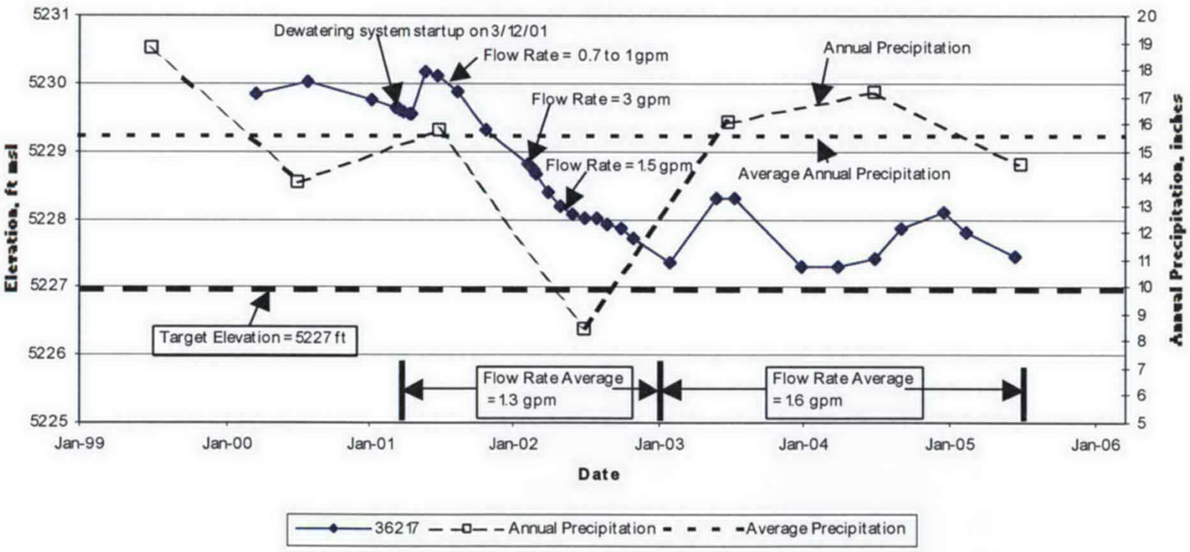
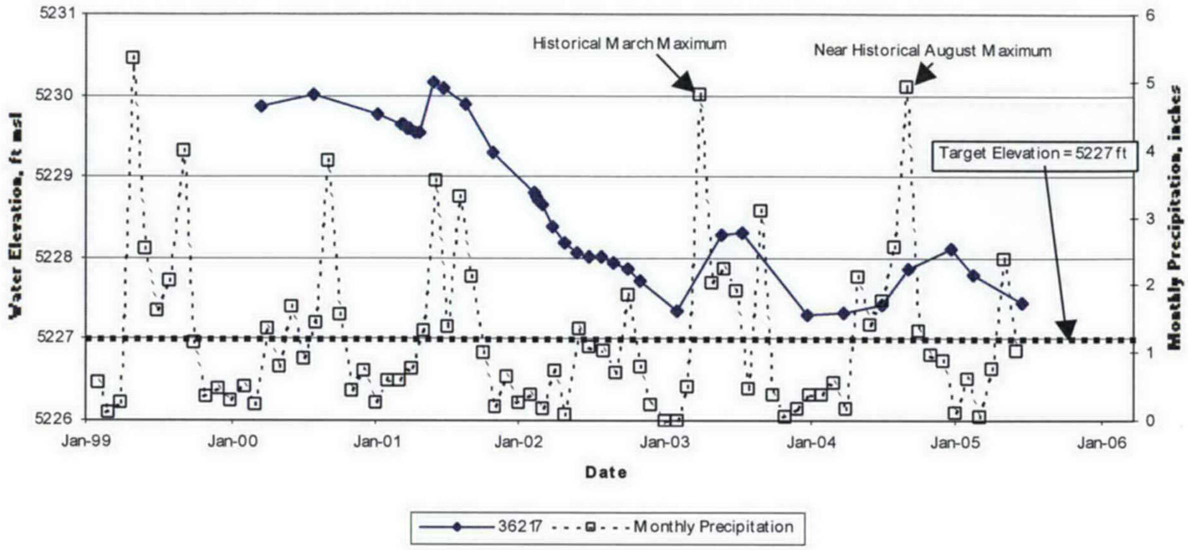


Figure 3-7
Complex Trenches Compliance Well 36217 Hydrograph and Monthly Precipitation



Appendix C

North Boundary Containment System

Summary of System Effectiveness

ROCKY MOUNTAIN ARSENAL

NORTH BOUNDARY CONTAINMENT SYSTEM (NBCS)

EVALUATION OF HYDROGEOLOGY, CSRG EXCEEDANCES IN DOWNGRADIENT CONFORMANCE WELLS, AND SYSTEM EFFECTIVENESS

FEBRUARY 2007

Prepared by

Rocky Mountain Arsenal
Remediation Venture Office

U.S. Department of the Army
Shell Oil Company
U.S. Fish and Wildlife Service

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1.0 Introduction

The following assessment is intended to provide sufficient documentation to address Regulatory Agency concerns and comments about the effectiveness of the North Boundary Containment System (NBCS) expressed during review of the RMA Draft 2005 Five-Year Review Report (FYRR), which for groundwater covers the period from FY2000 through FY2004. Some additional background information concerning RMA hydrogeology that is pertinent to the operation of the NBCS is also provided.

Detection of groundwater contaminants at concentrations above Containment System Remediation Goals (CSRGs) downgradient of the NBCS during the 5-year review period resulted in Regulatory Agency concerns that bypass or underflow might be occurring. The focus of this evaluation is on the NBCS conformance wells, which are located downgradient (north) of the NBCS slurry wall and recharge trenches, and unconfined Denver well pairs located adjacent to the NBCS slurry wall.

Based on historical data the RVO believes that the NBCS is effectively intercepting and treating the groundwater to meet the CSRGs and the system is working as intended in the ROD. Information that supports the RVO position and explains why underflow/bypass is not likely to be occurring is provided below. Some of the complicating factors affecting the assessment of the effectiveness of the NBCS in relation to the downgradient water-quality data are as follows:

- Complex hydrogeology of the NBCS area,
- Long duration of contaminant migration before installation of the NBCS,
- Numerous groundwater contaminants with a wide range of fate and transport properties,
- Effects of fresh water storage primarily in Basin C,
- Lower effectiveness of the NBCS during the first 13 years of operation, and
- Fluctuating groundwater levels related to intermittent surface water flow in First Creek.

Much of this information was presented to the Regulatory Agencies in a meeting on December 8, 2005 and in previous RMA Water Team meetings. In these previous meetings, the conclusions developed from the information were agreed to informally, but were not documented for the administrative record. The conclusions concerning effectiveness of the NBCS derived in these meetings and provided herein were included in previous NBCS Annual Operational Assessment Reports and in the Draft FYRR. As decided in the December 2005 meeting, the information presented here is provided to document RVO's conclusions concerning the effectiveness of the NBCS and to support the FYRR.

Following this section, the assessment is organized as follows:

- CSRG Exceedances in Downgradient Conformance Wells
    - Dieldrin North of NBCS
- Background Information
    - RMA Hydrogeology
    - Basin C/Basin F Historical Use
    - Effects of Basin C/Basin F Historical Use on Chloride at NBCS

  - Effects of Basin C/Basin F Historical Use on Water Levels/Flows at NBCS
  - NBCS Operations History
  - NBCS Hydrogeology
- Discussion of Five-Year Review Report Issues
  - Chloride and Sulfate Natural Attenuation
  - Potential Denver Formation Underflow
  - Unconfined Denver Formation Conformance Wells
  - Alluvial Conformance Wells
- NBCS Conclusions
- References

2.0 CSRG Exceedances in Downgradient Conformance Wells

The NBCS conformance well locations are shown on Figure 2-1. During the current FYR period, CSRG exceedances (excluding chloride and sulfate) have occurred in five downgradient alluvial conformance wells (37339, 23198, 24162, 37338, and 24166) and two downgradient Denver wells (23235 and 24191). Chloride concentrations exceed the CSRG in all downgradient conformance wells except well 24162 in 2002, 24166 in 2001 and 2002, and well 24191 in 2003 and 2004. Sulfate concentrations exceed the CSRG in the three downgradient Denver Formation conformance wells, and alluvial wells 37339 and 23253 (in 2003 only). Except for sulfate in the Denver wells, chloride and sulfate concentrations are decreasing overall due to decreasing concentrations in the NBCS effluent. The elevated sulfate concentrations in the Denver wells likely are naturally occurring.

Throughout the FYR period, reverse gradients have been maintained across the NBCS slurry wall in all alluvial well pairs and in all but one Denver well pair. Thus, the exceedances in the downgradient alluvial conformance wells are interpreted to be due to residual contamination. The exceedances in the two Denver wells are also interpreted to be due to residual contamination, in spite of the occurrence of a forward gradient at the NBCS slurry wall at one location. At this location, the upgradient wells meet CSRGs (except for chloride and sulfate).

The interpretation that residual contamination, rather than bypass, is responsible for the observed exceedances in the conformance wells is corroborated by the fact that a reverse gradient consistently was present in the alluvium and the unconfined Denver (where contaminated) at the slurry wall, and neither the alluvial conformance wells nor the Denver conformance wells contain mobile (relative to dieldrin) organic contaminants (such as chloroform and carbon tetrachloride) that are present upgradient of the NBCS. If contaminated groundwater was bypassing the NBCS, the mobile groundwater constituents would be expected to be present in the downgradient wells at concentrations equal to or lower than occur in upgradient wells. As these other mobile constituents are not present, and in some cases the concentrations of contaminants present are higher than upgradient concentrations, the exceedances are most likely due to residual contamination. DIMP is a mobile compound that was present at concentrations above the CSRG in two alluvial conformance wells and two Denver conformance wells during the FYR period, and will be discussed in more detail in the following sections. Continued monitoring of these wells is expected to demonstrate decreasing concentrations for most constituents, though dieldrin concentrations are expected to persist due to its strong tendency to sorb to organic matter in aquifer materials. Chloride and/or sulfate exceedances are expected to continue in the three downgradient Denver Formation conformance wells and in alluvial well 37339. Chloride and sulfate concentrations in the other alluvial conformance wells should continue to decrease due to the decreasing concentrations in the NBCS effluent.

Relevant information for each of the conformance wells with CSRG exceedances is summarized in Table 2.0-1 below. For several wells indicated below, fluoride was only exceeded in 2003, possibly due to higher water levels that year. A separate section (Section 2.1) discusses dieldrin in more detail because downgradient concentrations of this constituent are not decreasing as fast as the other more mobile compounds and may be of more concern.

Table 2.0-1. Summary of CSRG Exceedances in NBCS Conformance Wells.

Well	Exceedance	Formation	Hydrogeology Comment	Concentration Comment
37339	DIMP, Chloride Fluoride, Sulfate	Alluvium	Clay; alluvium unsaturated upgradient; reverse gradient in upgradient well pair.	DIMP lower (< CSRG in 2004); chloride lower; sulfate same; chloride concentration higher than upgradient; no other organic compounds detected.
23198	DIMP, Dieldrin, Chloride, Fluoride	Alluvium	Silt and clay upgradient; reverse gradient in upgradient well pair.	DIMP lower (< CSRG in 2004); dieldrin lower (< PQL in 2003, 2004); chloride lower; no other organic compounds detected.
23253	Chloride, Sulfate	Alluvium	Sand; reverse gradient in upgradient well pair.	Chloride lower; sulfate lower; no organic compounds detected.
24006	Chloride, Fluoride (03)	Alluvium	Sand; reverse gradient in upgradient well pair.	Chloride lower; no organic compounds detected.
24162	Dieldrin, Chloride, Fluoride (03)	Alluvium	Sand; reverse gradient in upgradient well pair.	Dieldrin lower; chloride lower; no other organic compounds detected.
37338	Dieldrin, Chloride, Fluoride (03)	Alluvium	Sand; reverse gradient in upgradient well pair.	Dieldrin higher; chloride lower; no other organic compounds detected.
24166	Dieldrin, Chloride, Fluoride	Alluvium	Sand; reverse gradient in upgradient well pair.	Dieldrin same; chloride higher; no other organic compounds detected.
23226	Chloride, Fluoride (03), Sulfate	Denver	Sandstone; reverse gradient in upgradient Denver well pairs.	Chloride lower; sulfate same; no organic compounds detected.
23235	DIMP, 12DCLE,	Denver	Thin sandstone, possibly discontinuous; forward	DIMP higher concentrations than upgradient; DIMP lower

Well	Exceedance	Formation	Hydrogeology Comment	Concentration Comment
	Chloride, Sulfate		gradient in upgradient Denver well pair that meets CSRGs.	since 2003; 12DCLE lower; chloride lower; sulfate same; no other organic compounds detected.
24191	DIMP, Chloride, Sulfate	Denver	Sandstone; reverse gradient in upgradient Denver well pair	DIMP lower; chloride lower; sulfate lower.

The term "residual contamination" refers to contamination present downgradient (north) of the NBCS slurry wall that migrated there either before the NBCS was completed in 1981 or potentially bypassed the system before a reverse hydraulic gradient was established along the entire length of the slurry wall in 1992. Two mechanisms affect the migration of the residual contamination. One mechanism is sorption/desorption of dieldrin in relatively permeable alluvial sand sediments, and the second mechanism is slower groundwater flow and contaminant migration of more mobile contaminants such as DIMP, chloride, and fluoride in finer grained alluvial silt and clay sediments present in wells at the west end of the NBCS and in Denver Formation sandstones, both of which have much lower hydraulic conductivities than the alluvial sands. Additionally, the Denver sandstones may be discontinuous within a lower permeability claystone matrix such that lateral migration is limited, and the residual contamination is relatively isolated. These Denver sandstones likely became contaminated due to downward migration from the overlying contaminated alluvium before the NBCS was installed.

Due to the presence of residual contamination, some wells may not be suitable to use as conformance wells because they are not representative of current system effectiveness. These wells include Denver wells 23235 and 24191, and alluvial wells 24162, 24166, 37338, and 37339. In some cases, the wells may be not be representative of system effectiveness for a certain compound (e.g., dieldrin), but may be representative for other compounds. Additionally, naturally occurring sulfate in the three Denver wells and alluvial well 37339 causes these wells to not be representative of system effectiveness with respect to sulfate (groundwater flow in the Denver Formation bedrock upgradient of alluvial well 37339 likely causes its elevated sulfate concentrations). Consequently, alternate conformance wells and alternative analyte lists for the existing conformance wells will be considered when revising the LTMP.

No conformance monitoring between wells 24162 and 37338 was specified in the 1999 LTMP because historical data showed that contaminant concentrations in wells 24163 and 24164 had decreased to below CSRGs prior to or by 1999. For example, DIMP concentrations had been below the CSRG in wells 24163 and 24164 since 1994, and NDMA concentrations decreased to below the PQL by 1999 in response to installation of the UV oxidation treatment system in 1997. The conformance well network in this area will be revisited during the 2006/2007 LTMP revision.

2.1 Dieldrin North of NBCS

CSRG exceedances of dieldrin in downgradient wells at the NBCS have been relatively consistent in two areas. One area is located just east of D Street at well 24162 (Figure 2-2), and the other is located at the east end of the system near First Creek at wells 37338 and 24166 (Figure 2-3). As described above, the hydrogeological and chemical data for these areas support the conclusion that these exceedances are due to residual contamination rather than bypass of the system. The continued presence of dieldrin at elevated levels is interpreted to be due to desorption of residual contamination from secondary sources that were present north of the NBCS before the system was installed and before the reverse gradient was established across the entire system in 1992.

The same phenomenon applies to both dieldrin exceedance areas, but the plume at the east end of the NBCS will be discussed here because it extends a longer distance downgradient and concentrations have not displayed steady decreases (Figure 2-4). The dieldrin concentrations in the wells near D Street are decreasing overall (Figure 2-5) and meet the performance criteria for conformance wells. Consequently, further explanation is not necessary. At the east end of the NBCS, fluctuating water levels due to surface water flow in First Creek appear to be mobilizing residual dieldrin from above the typical water table during periods of higher water levels. This helps explain the observed variability in the dieldrin concentrations and the absence of an overall decreasing trend downgradient of the east end of the NBCS.

Dieldrin is more persistent than other more mobile contaminants, such as DIMP, carbon tetrachloride (CCL4), chloroform, and PCE, because of lower aqueous solubility and higher partition coefficients. The solubilities and partition coefficients for dieldrin, DIMP, and carbon tetrachloride are provided in Table 2.1-1 below. Higher organic carbon concentrations are present in the aquifer sediments north of the NBCS than in other areas of RMA, including in downgradient well 37338. This facilitates greater sorption and retardation of dieldrin migration and extends the duration of desorption back into the aquifer. The RMA Remedial Investigation Summary Report, Appendix E (Ebasco 1992) provides information on the partition coefficients and contaminant fate and transport behavior of RMA contaminants, including dieldrin, which is an organochlorine pesticide (OCP). This report states that once OCPs are mobilized in the subsurface, they may accumulate as secondary sources at optimal locations along their migration pathways (Ebasco 1992). Apparently, the higher organic carbon content of the aquifer sediments north of the NBCS is conducive for accumulation of secondary sources of dieldrin. Mackay and Cherry (1989) stated that secondary sources formed by sorption to saturated and unsaturated aquifer sediments may be responsible for the slow release of OCPs significant distances from their original disposal areas.

The Retardation Factor (Rf) is used to compare relative migration rates of groundwater contaminants due to adsorption (or attachment) to aquifer sediments. An Rf of 1 means that there is no retardation and the contaminant migrates at the same rate as the groundwater. An Rf of 5 means that the contaminant migrates 5 times slower than the groundwater. The Rf also indicates the relative rate of desorption of different compounds from the aquifer sediments into the groundwater, with a higher Rf indicating slower desorption. The Rfs of dieldrin, DIMP, and carbon tetrachloride are estimated in Table 2.1-1. The dieldrin Rf is estimated to be 45.7, which is an order of magnitude higher than the Rfs of DIMP and carbon tetrachloride. These properties of dieldrin and of the aquifer north of the NBCS, plus the fluctuating water levels in the recharge trenches caused by flow in First Creek likely explain the slower cleanup of the dieldrin plume in this area. Thus, the RVO believes the exceedances of dieldrin in NBCS conformance wells do not reflect bypass of the NBCS.

Table 2.1-1. Retardation Factors for Dieldrin, DIMP, and Carbon Tetrachloride

Retardation Equation
Rf = 1 + (Db)(Koc)(foc)/n

Where:
Db = assumed bulk density = 1.85 g/cm3
Koc = Organic carbon partition coefficient (7244 for dieldrin, 123 for DIMP, 355 for carbon tetrachloride) (RISR, Ebasco 1992, Appendix E, Table RISR E.2-5)
foc = fraction of organic carbon content in soil (%TOC/100) = 0.001 in well 37338 (Offpost RI, ESE 1988, Table 12.6-3)
n = assumed effective porosity = 0.3

Dieldrin
Aqueous solubility = 0.16 mg/l
Rf = 45.7
DIMP
Aqueous solubility = 1,500 mg/l
Rf = 1.76
Carbon Tetrachloride
Aqueous solubility = 800 mg/l
Rf = 3.19

Historically, there were 20 years or more of dieldrin migration through and likely sorption to the aquifer sediments north of the NBCS before a reverse gradient was established at the east end of the NBCS in 1992. The increasing dieldrin concentration trend in some of the wells downgradient of the NBCS is consistent with slower migration of dieldrin and later plume arrival. Additionally, water levels were higher in the 1970s, 1980s, and early 1990s, causing dieldrin to sorb to the sediments above the current water table. Short-term increases in dieldrin concentrations in downgradient wells were observed when the recharge trenches were started up in 1989 and 1990, suggesting mobilization of dieldrin from above the earlier water table and further supporting this interpretation. Intermittent flushing of residual dieldrin likely occurs when seasonal variation of water levels in NBCS recharge trenches of 6-7 feet (due to flow in First Creek) causes the water table to rise above typical levels (Figure 2-6).

The hydrogeology of the area corroborates the interpretation that the dieldrin exceedances are due to residual contamination rather than bypass of the NBCS. The east end of the NBCS slurry wall is keyed 10 to 20 feet into bedrock. It was extended below any sandstone zones that were encountered during exploratory drilling. Thus, the bedrock material below the bottom of the slurry wall is comprised mainly of low permeability claystone. A consistent reverse gradient has been maintained at the east end of the slurry wall since 1992. Thus, bypass or underflow in the alluvium is extremely unlikely.

Underflow in the underlying Denver Formation also is extremely unlikely because the slurry wall is keyed into low permeability claystone below any sandstone zones that could facilitate underflow. The predominantly claystone bedrock has much lower hydraulic conductively than the overlying alluvium where a reverse gradient exists at the slurry wall. Additionally, dieldrin has not consistently been detected in Denver wells, including the Denver extraction wells when they were used for a short period in the 1980s. Dieldrin has never been detected in unconfined Denver well 37376 (north of NBCS adjacent to well 37338), which was sampled 8 times between 1987 and 1994, with no dieldrin detections. Of the few sporadic historical dieldrin detections that occurred in 15 other Denver wells near the east end of the NBCS, all but one was identified as questionable in the RMA database. Thus, the data indicate that dieldrin is not present in the Denver Formation wells in this area, and therefore underflow of dieldrin is not likely.

Dieldrin is not the only contaminant present upgradient of the NBCS; there are 29 compounds with CSRGs at the NBCS. Comparison of the upgradient and downgradient distributions of these other compounds with dieldrin helps to evaluate potential bypass. Other organic contaminants (e.g., DIMP and carbon tetrachloride) are present upgradient of the NBCS slurry wall, but not present downgradient. If more mobile contaminants are not bypassing the NBCS, it is unlikely that dieldrin would be.

For the reasons described above, sorption and desorption of dieldrin by the alluvial aquifer materials north of the NBCS, plus the fluctuating water levels in the recharge trenches caused by flow in First Creek, likely explain the slower cleanup of the dieldrin plume in this area. Thus, the RVO believes the exceedances of dieldrin in NBCS conformance wells do not reflect bypass of the NBCS and therefore, are not considered reason for concern.

3.0 Background Information

The following sections are presented in a summary outline format to provide supporting information and facts for the previous sections. Section 3 concerns background information and history relevant to the observed concentration trends at the NBCS. Section 4 addresses the specific FYRR concerns. Section 5 provides conclusions about NBCS effectiveness, and Section 6 contains references.

3.1 RMA Hydrogeology

- Regional alluvial groundwater flows occur in the First Creek and Irondale Flow Systems (Figures 3-1 and 3-2). Flows are 200-250 gpm in First Creek and about 2000 gpm in Irondale Flow System (Figure 3-3) (MK 1993).
- Alluvial flow in the Central Flow System is derived from limited local recharge and is small (50 gpm or less) compared to the regional flows (Figure 3-3) (MK 1993).

- Soil covers and RCRA-equivalent covers will reduce recharge in source areas, causing passive dewatering of the uppermost aquifer (Foster Wheeler 1996), reduce gradients/contaminant migration, and reduce gradients to the exterior of the Central Remediation Area, shifting plumes farther away from internal system and boundary system edges and reduce potential for bypass around the ends of these systems.
- A portion of the groundwater flow in the Central Flow system emanating from the Basins C and F area merges with the flow in the First Creek Flow System at the NBCS. Much higher levels of contamination are associated with the Basins C and F flow than the First Creek flow.

3.2 Basin C/Basin F Historical Use (MK and Foster Wheeler 1996)

- 1953: Basin C constructed to receive liquid wastes from South Plants and overflow from Basin A. Basin C liquid chloride concentrations were 3000 to 4000 mg/l.
- Basin C was unlined and the underlying soils are sandy. Consequently, seepage from Basin C resulted in chloride concentrations in groundwater north of Basin C similar to the liquid waste concentrations in Basin C.
- 1955-1956: Chloride concentrations in groundwater downgradient of Basin C in Sections 23 and 26 ranged from 3000 to 4000 mg/ L (Petri and Smith 1956).
- 1956: Water disposal from South Plants transferred from the unlined basins (Basins A, B, C, D, and E) to lined Basin F at end of 1956.
    - Chloride concentration in Basin F liquid increased over time from 3,000 mg/l to levels greater than 130,000 mg/l due to evaporation (Figure 3-4).
- 1957- 1975: Basins C, D, E (primarily C) used for fresh water storage (low in CL) periodically between 1957 and 1975. Fresh water concentrations were low in chloride (< 100 mg/l)
- A high percentage of water was lost to seepage. Average seepage from Basin C estimated at 472 gpm between 1969 and 1975. This seepage recharged the groundwater and caused groundwater levels to rise near Basin C. Some of the seepage-related groundwater flow went to the NWBCS and some went to the NBCS.
- 1982: RMA production activities ended in 1982 and
- 1989: Basin F was drained in 1989.

3.3 Effects of Basin C/Basin F Historical Use on Chloride at the NBCS

- Historical use of Basins C and F and the associated chloride concentrations indicate the relative age of groundwater contaminants at the NBCS.
- Some of the groundwater contaminants detected above CSRGs downgradient of the NBCS are considered to be older contamination that was already downgradient of the NBCS before the NBCS was installed.
- Intermittent storage of fresh water from the South Lakes (which has low chloride concentrations) in Basin C and subsequent seepage caused chloride levels in groundwater to be low (< 200 mg/L) intermittently near Basin F until 1975, when this practice ended (Figure 3-5).
- This caused chloride concentrations to be low at the NBCS (~ 200 mg/l in the NBCS influent and effluent) when the pilot system was installed in 1979 and the system was extended to its current configuration in 1981. Figure 3-6 shows the NBCS effluent

chloride concentrations from FY1983 through FY2006). Between 1979 and 1983 the chloride concentrations likely were similar.

- Chloride levels near Basins C and F increased after 1975 due to the presence of a residual mass of chloride under Basin C and leakage of Basin F (Figure 3-5).
- Due to the increase in chloride concentrations near Basin F after 1975, chloride concentrations in the NBCS influent/effluent began to rise in 1985 and peaked at 490 mg/l in October 1997 (Figure 3-6). There is an approximate 10-year groundwater travel time from Basin F to the NBCS.
- After peaking in 1997, NBCS influent/effluent chloride concentrations decreased to below the CSRG (250 mg/L) during FY2005 (Figure 3-6) and are expected to remain below the CSRG unless NBCS extraction well flow rates are increased in high chloride concentration areas.
- Elevated chloride concentrations in downgradient NBCS conformance well 37339 indicate that the groundwater contamination in this area is representative of the groundwater contamination present at the NBCS location in the late 1960s and early 1970s, before the NBCS was installed. Figure 3-7 shows the well locations near the slurry wall and Figure 3-8 shows the chloride concentrations in the wells.
- These chloride data indicate that exceedance of CSRGs in well 37339 may be explained by the presence of older contamination that pre-dates the NBCS and does not indicate current bypass of the NBCS. DIMP concentrations in well 37339 decreased to below the CSRG in 2004, however.
- Historical operation of the NBCS and achieving a reverse hydraulic gradient, which is the primary criterion for system effectiveness, is discussed below.

3.4 Effects of Basin C/Basin F Historical Use on Water Levels/Flows at NBCS

- Since fresh water storage in Basin C ended in 1975, water levels have fallen about 10 feet between Basin F and the NBCS (Figure 3-9).
- The falling water levels north of Basins C and F have caused the total NBCS flow rate to decrease from over 400 gpm to approximately 200 gpm.

3.5 NBCS Operations History (Thompson et al. 1985)

- Pilot system operational in 1979
  - Slurry wall was installed from D Street west to the current bend in the slurry wall.
  - Pilot system slurry wall was not keyed very far into bedrock or below subcropping sandstones.
- NBCS slurry wall was extended to current configuration in 1981 (from D Street to east end, and from bend to west end) and is over 7,100 feet long.
  - Both ends of the slurry wall were keyed into bedrock highs where the alluvium is unsaturated and the groundwater is uncontaminated. Thus, the NBCS slurry wall extends past the edges of the plumes.
  - The bottom of the slurry wall was keyed 10 to 20 ft into bedrock and below subcropping sandstones.
  - A total of 35 alluvial and 19 Denver extraction wells were installed
  - A total of 38 recharge wells were installed

- Denver extraction wells were found to be counterproductive as they pulled alluvial contamination downward into the unconfined Denver zone. Consequently, the Denver extraction wells were shut down in 1985 (PMRMA 1987).
- The recharge wells were ineffective due to being too far from the slurry wall, poor aquifer properties at the west end of the system, and plugging problems. Thus, a reverse hydraulic gradient was not achieved during the 1980s.
- The NBCS reduced contaminant migration, but underflow/bypass of contaminants likely occurred, especially in the pilot portion of the slurry wall, until Interim Response Action (IRA) improvements were operational and a reverse hydraulic gradient was achieved along the entire length of the slurry wall in 1992.
    - IRA improvements:
        - Recharge trenches 1-10 (west 1/2), completed December 1988
        - Recharge trenches 11-15 (east 1/2), completed May 1990
        - Reverse gradient established across whole system in the alluvium and most of the unconfined Denver Formation in 1992.
        - A flat to small forward gradient occurs in two Denver well pairs adjacent to the slurry wall (23540/23541 and 23542/23543), only one of which is contaminated above CSRGs.
- Since 1992, a reverse hydraulic gradient has been consistently maintained in the alluvium and underflow/bypass in the alluvium has been effectively eliminated (NBCS OARs).
- Hydraulic gradient and underflow in the unconfined Denver Formation is addressed below.
- Recent operations
    - Two upgradient (South Channel) extraction wells were added in 2002 to keep upgradient plumes from migrating eastward into less contaminated area upgradient of the NBCS, to provide operational flexibility, and help maintain the reverse gradient if water levels fall
    - To improve efficiency, currently operating 11 extraction wells.
    - Extraction well and influent concentrations of most contaminants have decreased significantly due to implementation of the Basin F IRA in 1989, which included operation of a groundwater extraction well, draining of Basin F and incineration of Basin F liquid, and containment of contaminated soil; and implementation of the final soil remedy thus far.

3.6 NBCS Hydrogeology (Thompson et al. 1985)

- Alluvial aquifer varies from east to west and north to south.
- Alluvial extraction wells
    - West side – thinner, finer grained sands
    - East side – thicker, coarser grained sands.
- Alluvium is composed of clay and silt and is unsaturated downgradient of the western portion of the slurry wall.
- Hydraulic conductivities of the underlying Denver sandstones and claystones are lower than the alluvial sands. Denver hydraulic conductivity ranges from 10^{-4} to 10^{-6} cm/sec compared to 10^{-1} to 10^{-3} cm/sec in the alluvium.
- Uppermost Denver sandstones underlying the NBCS likely subcrop south of the RMA boundary (see Figures 4-3 and 4-9).

    - Any contaminated flow in these sandstones would discharge into the alluvium south of the boundary, where it can more readily be monitored (i.e., there are more alluvial monitoring wells than Denver wells).
- Gypsum (calcium sulfate) present in the Denver Formation (frequently observed in Denver Formation borelogs) causes high naturally occurring sulfate levels in groundwater.

4.0 Discussion of Five-Year Review Report Issues

The FYRR issues discussed below in Section 4 include chloride and sulfate natural attenuation, potential Denver Formation underflow, unconfined Denver Formation conformance wells, and alluvial conformance wells. The conformance wells, which are located downgradient of the NBCS slurry wall and recharge trenches, are not required to meet CSRGs, but should show decreasing concentration trends when concentrations are above CSRGs.

4.1 Chloride and Sulfate Natural Attenuation (MK and Foster Wheeler 1996)

- Meeting chloride and sulfate CSRGs in the NBCS effluent is based on decreasing groundwater flow from the Basin F area, which is different than what is considered "natural attenuation" based on EPA guidance that post-dates the ROD. The RVO will clarify this issue in the FYRR.
- Time-frame predictions for meeting CSRGs in the NBCS effluent were conservative and do not rely on decreasing concentrations upgradient.
- Meeting CSRGs for chloride and sulfate in upgradient wells is not required for meeting the ROD requirement of meeting CSRGs in NBCS effluent.
- Upgradient concentrations may actually increase in the short-term because of decreased recharge, which causes dilution of chloride in the Basins C and F area. However, the overall contaminant mass flowing toward the NBCS is expected to decline. The concentration trends in the NBCS influent/effluent and individual upgradient wells have been consistent with predictions in the chloride and sulfate report (MK and Foster Wheeler 1996).
- Sulfate concentrations in the NBCS effluent have been below the CSRG (540 mg/L) since the ROD was issued. Chloride concentrations decreased to below the CSRG in 2005 (Figure 3-6). Therefore, meeting the CSRGs in the NBCS effluent has occurred much sooner than predicted.
- Downgradient conformance wells generally show decreasing chloride and sulfate concentration trends at varying rates that depend on the localized aquifer properties and groundwater flow rates. CSRG exceedances and concentration trends are discussed in Sections 4.3 and 4.4.

4.2 Potential Denver Formation Underflow

- IRA recharge trench startup study conducted in 1990.
    - Water-level response similar to adjacent alluvial wells in most unconfined Denver wells.
    - Less response in semi-confined Denver sandstones (cemented layer is present above sandstones in places).

- No response in confined Denver sandstones.

- Unconfined Denver well 2000 field investigation results (Attachment A) (presented at September 7, 2000 meeting with Regulatory Agencies).
  - Monitored 7 well pairs in west part of slurry wall where slurry wall is not keyed as far into bedrock (Figure 4-1).
  - The Denver well pairs are located halfway between recharge trenches where the trenches' effects on the reverse gradient are the least, and monitor the worst-case reverse gradient locations.
  - Reverse gradient present in all but 2 well pairs. Concentrations less than CSRGs in one pair (23542/23543) and greater than CSRGs in one pair (23540/23541).
  - Wells 23540/23541 show a flat to small forward gradient. Very small amount of potential forward flow (estimated as 0.01 gpm or less) at wells 23540/23541 (Attachment B).
  - Groundwater concentrations are not expected to exceed CSRGs at RMA boundary. Although the original mass balance calculation in Attachment B may have overestimated the concentration reduction due to mixing with recharge water upgradient of the RMA boundary, only a very small stream of contaminated water potentially could discharge into the alluvium (which contains with much greater treated recharge flow) from this area and would be affected by horizontal and vertical dispersion. Groundwater modeling could provide a better estimate of downgradient concentrations, but many input parameters are unknown. RVO believes that groundwater monitoring better addresses the issue.
  - Denver sandstone at the slurry wall in wells 23540/23541 may not extend to RMA boundary, which would further reduce contaminated flow reaching the alluvium. Figure 4-2 shows the location of selected cross sections and Figure 4-3 shows section A-A', which includes wells 23540/23541.
  - Figure 4-4 shows decrease in DIMP concentrations in well 23540 (located on the north side of the slurry wall), which is one criterion for demonstrating system effectiveness.
  - At well pair 23540/23541, concentrations of most constituents (except chloride) are lower in the upgradient well than in the downgradient well. This relationship is not readily explained by bypass, which is expected to lead to lower concentrations in the downgradient well.
  - Dieldrin concentrations display a slight increase on the downgradient side of the slurry wall in well 23540, but are lower on the upgradient side in well 23541. This may be caused by relatively stagnant flow, which is supported by other information presented herein.
  - Monitoring data in downgradient alluvial well 23198 helps support the expectation of no CSRG exceedances due to underflow at RMA boundary (Figure 4-5). DIMP and dieldrin concentrations in well 23198 decreased to below the CSRG/PQL during this FYR period. Although well 23198 may not be directly downgradient of well 23540, it and another well located farther downgradient (37374) meet CSRGs. The conformance well network will be reviewed during the LTMP revision and additional wells will be considered in this area.

- An upward hydraulic gradient from the Denver Formation to the alluvium is typically present on the extraction side of the slurry wall. It provides hydraulic capture of contaminants in the unconfined Denver zone.
- A downward gradient is present on the recharge side of the slurry wall and provides flushing of the downgradient aquifer.
- The 2002, 2003, and 2004 monitoring results were similar to those for 2000.
- The 2000 conclusions are still valid:
  - A reverse hydraulic gradient is maintained for most of the unconfined Denver well pairs.
  - Based on vertical and lateral gradients and the water-quality results, hydraulic control of the unconfined Denver Formation is being maintained, except at well pair 23540/23541 where there may be a small amount of northward flow.
  - The quantity of potential flow in the Denver Formation at well pair 23540/23541 is very small and CSRGs likely would not be exceeded where the Denver flow discharges into the alluvium (likely onpost).
  - Monitoring data support that CSRGs are not exceeded at the RMA boundary downgradient of wells 23540/23541.

4.3 Unconfined Denver Formation Conformance Wells

- Well 23226
  - Lower hydraulic conductivity than alluvium, $K = 2.2 \times 10^{-4}$ cm/sec (ESE 1988)
  - Concentrations below CSRGs except for CL, SO4, and fluoride (in 2003 only). Chloride and sulfate concentrations are relatively stable.
- Well 23235
  - Thinner, finer grained sandstone than in well 23226 (Figure 4-6). Hydraulic conductivity likely is lower than in well 23226.
  - Concentrations above CSRGs for DIMP and 1,2-dichloroethane (12DCLE) (and CL and SO4).
  - Concentrations of DIMP and 12DCLE have been decreasing (Figures 4-7 and 4-8).
  - DIMP concentrations are higher in well 23235 than in upgradient extraction wells.
  - Concentrations in upgradient correlative sandstones at slurry wall (wells 23542/23543) are below CSRGs for DIMP and 12DCLE. Sandstone in well 23235 may not be connected to the sandstone at the slurry wall (Figure 4-9).
  - <u>Conclusions</u>: The contamination in well 23235 is older and slower moving and may have migrated downward from the alluvium when alluvial concentrations were high. The contamination appears isolated and the well is not indicative of current system effectiveness.
- Well 24191
  - Lower hydraulic conductivity than alluvium, $K = 7 \times 10^{-5}$ cm/sec (ESE 1988)
  - Concentrations above CSRG for DIMP, but are decreasing (Figure 4-10).
  - Chloride and sulfate are above CSRGs, but concentrations are decreasing. Chloride concentrations were below CSRG in 2003 and 2004.
  - Reverse gradient is present in Denver well pair at slurry wall (24202/24203) (Figure 4-11).
- <u>Unconfined Denver Formation Conformance Well Conclusions</u>:

  - Sandstone in well 23226 likely is connected to correlative sandstone at slurry wall and is indicative of system performance.
  - Wells 23235 and 24191 do not appear to be connected to correlative sandstones at the NBCS slurry wall.
  - The contamination in Denver wells 23235 and 24191 is older and slower moving than the alluvial contamination and probably migrated downward from the overlying alluvium before the NBCS was installed when alluvial concentrations were high. The contamination appears isolated and the wells are not indicative of current system effectiveness.

4.4 Alluvial Conformance Wells

- Downgradient of Western Part of NBCS
  - Well 37339 has clay lithology
    - Chloride level indicates contamination is from late 1960s/early 1970s, before NBCS was installed (Figure 3-8)
    - DIMP exceeded the CSRG in 2000, 2002, and 2003, but not in 2001 and 2004.
    - Concentrations of chloride, fluoride, and sulfate are greater than CSRGs.
    - Chloride, fluoride, and DIMP CSRG exceedances are caused by slow migration through bedrock and alluvium downgradient of the slurry wall.
    - Sulfate CSRG exceedance likely caused by naturally occurring sulfate in Denver Formation flow upgradient of well 37339.
  - Well 23198 has interbedded sand, silt, and clay lithology
    - Upgradient the alluvium may be unsaturated.
    - DIMP exceeded the CSRG in 2000 through 2003, but not in 2004.
    - Dieldrin exceeded the PQL in 2000 through 2002, but decreased to below the PQL in 2003 and 2004.
    - Concentrations of chloride and fluoride are greater than CSRGs
    - Chloride concentrations are decreasing, but fluoride is increasing slightly.
    - DIMP and fluoride CSRG exceedances may be caused by slow migration through bedrock and alluvium
- Downgradient of Middle Part of NBCS
  - Wells 23253, 24006, 26162 have sand lithology
    - Concentrations above the PQL for dieldrin in well 24162 in all monitoring events. It displays a decreasing concentration trend (Figure 2-5) consistent with conformance well criteria and is not investigated further. For more information, please see Section 2.1.
    - No conformance monitoring between wells 24162 and 37338 was specified in 1999 LTMP because historical data showed no CSRG exceedances since the NBCS was completed (conformance well network will be reviewed during 2006/2007 LTMP revision).
    - Wells 23253, 24006 and 24162 exceeded the CSRG for chloride in most or all monitoring events, but show decreasing trends. Wells 24006 and 24162 exceeded the CSRG for fluoride in 2003. Well 23253 exceeded the sulfate CSRG in 2003.
- Downgradient of Eastern Part of NBCS

- Wells 24166 and 37338 have sand lithology
    - Dieldrin concentrations above PQL in well 37338 in all monitoring events (Figure 2-4). Well 24166 was above the PQL for dieldrin in 2003 and 2004.
    - Well 24166 was above the CSRG for chloride in 2000, 2003, and 2004; and well 37338 was above the CSRG in all 5 monitoring events, but shows a decreasing trend. Wells 24166 and 37338 were above the fluoride CSRG in 2003.

- Discussion of dieldrin exceedances in conformance wells
  - Dieldrin exceedances in conformance wells 24162, 24166, and 37338 are likely due to residual contamination downgradient of the NBCS slurry wall that was present before the NBCS was installed, and not bypass of the system.
  - More mobile contaminants present upgradient of the slurry wall are not detected above CSRGs downgradient.
  - At the east end of the NBCS, intermittent flushing of the unsaturated zone due to intermittent flow in First Creek and the resulting 6-7 feet of variation in the water levels (Figure 2-6) may be mobilizing residual dieldrin present above the typical water table. Residual dieldrin is present above the current water table because water levels were higher when the plume migrated Offpost before the NBCS was installed. This likely explains the variable concentrations in downgradient wells.
  - Details are provided in Section 2.1.

5.0 NBCS Conclusions

- Wells 37339, 23235, 24191, 24162, 37338, and 24166 are not indicative of NBCS performance, but useful for indicating trends where concentrations are still above CSRGs. In some cases, they may not be representative of system effectiveness for certain analytes, but may be representative for others.
- CSRG/PQL exceedances of 12DCLE, chloride, dieldrin, DIMP, fluoride, and sulfate in downgradient wells are not indicative of bypass or underflow.
- NBCS meets Offpost OU RS/S effectiveness criteria.
  - Effluent is in compliance with CSRGs.
  - Hydraulic gradients are acceptable.
    - Reverse gradient is maintained in alluvium and majority of unconfined Denver Formation.
    - Flat to small forward gradient occurs in 1 unconfined Denver well pair with CSRG exceedances.
      - Concentration trends are monitored in these wells and are decreasing for most compounds.
      - Concentrations of most constituents (except chloride) are higher in the downgradient well than in the upgradient well. This relationship is not readily explained by bypass, which is expected to lead to lower concentrations in the downgradient well.
      - Monitoring data indicate that CSRGs are met at the RMA boundary downgradient of this well pair, but the well network will be re-evaluated.

  - Upward gradient from the unconfined Denver to the alluvium in most well pairs on the extraction-well side of slurry wall indicate hydraulic capture of unconfined Denver Formation contamination.
  - Conformance wells either are below CSRGs, show decreasing trends, and/or have concentrations above CSRGS for a few compounds. Slow migration through fine-grained sediments or desorption of residual contamination present downgradient of the NBCS slurry wall likely cause these exceedances and are not representative of system effectiveness.
- The NBCS is meeting the intent of the ROD and meeting the objective of containment as defined in the Onpost ROD.

6.0 References

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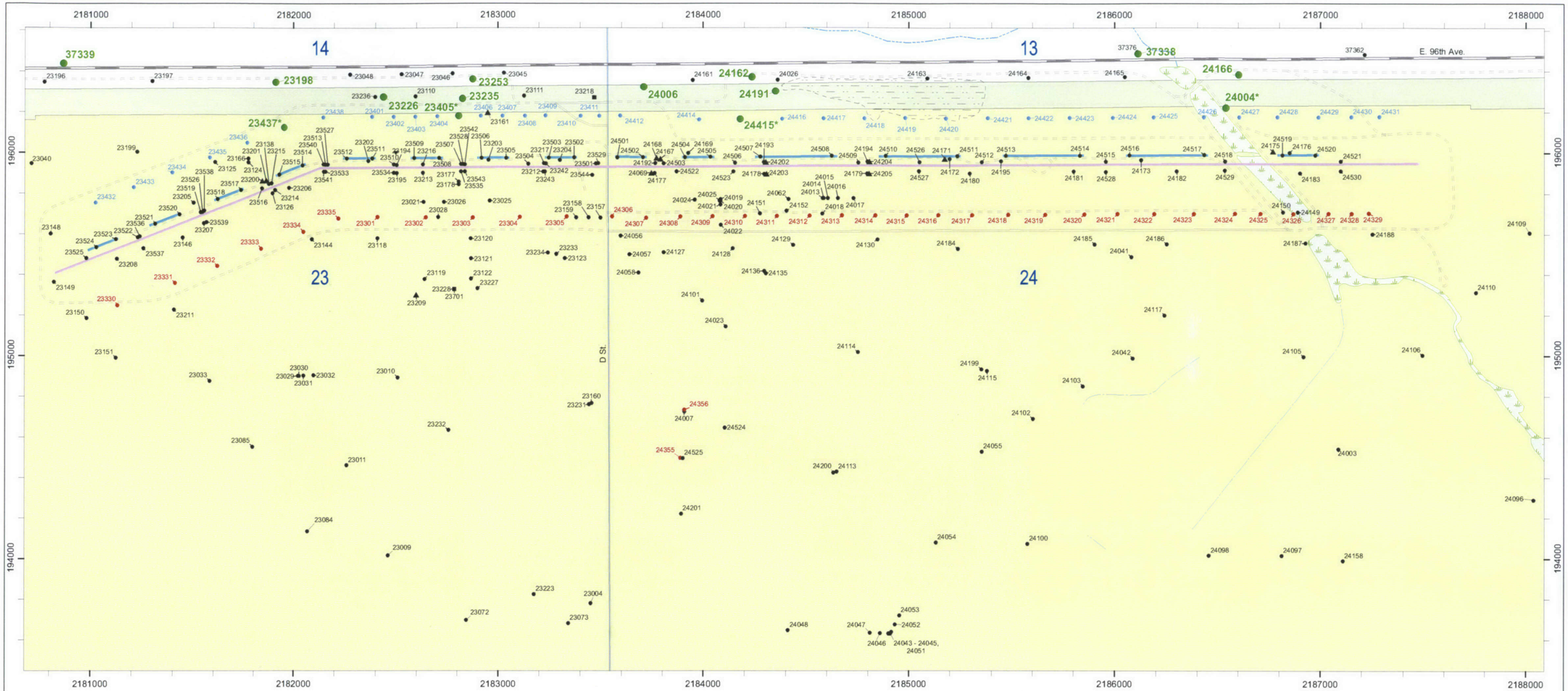

FY04 North Boundary Monitoring Well Network of the Unconfined Aquifer Locations Of NBCS Conformance Wells

Legend

- Rocky Mountain Arsenal
- USFWS National Wildlife Refuge
- Dry Lake Areas
- Wetlands
- Lakes and Ponds
- Section Lines
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Conformance Wells (*- Replaces well to be closed)
- Extraction Wells
- Former Recharge Wells Used For Monitoring

Monitoring Wells

- Confined Flow System
- Unconfined Flow System
- Questionable Unconfined Flow System
- Questionable Flow System

N

0 250 500
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: USGS, DPRA, Inc., Washington Group, RMA Environmental Database, U.S. Army, Shell Chemical

Remediation Venture Office GIS

GIS Analyst: H. Kikel	Figure 2-1
Date: 10/27/2006	
Scale:	
Prepared For: E. Kaastrup	
Approved:	

DPRA

Rocky Mountain Arsenal Remediation Venture Office

File Location: M:\projects\sitereview_00_04\mxds\nbcs_conformance_wells_17x11.mxd

North Boundary Containment System Wells Near D Street

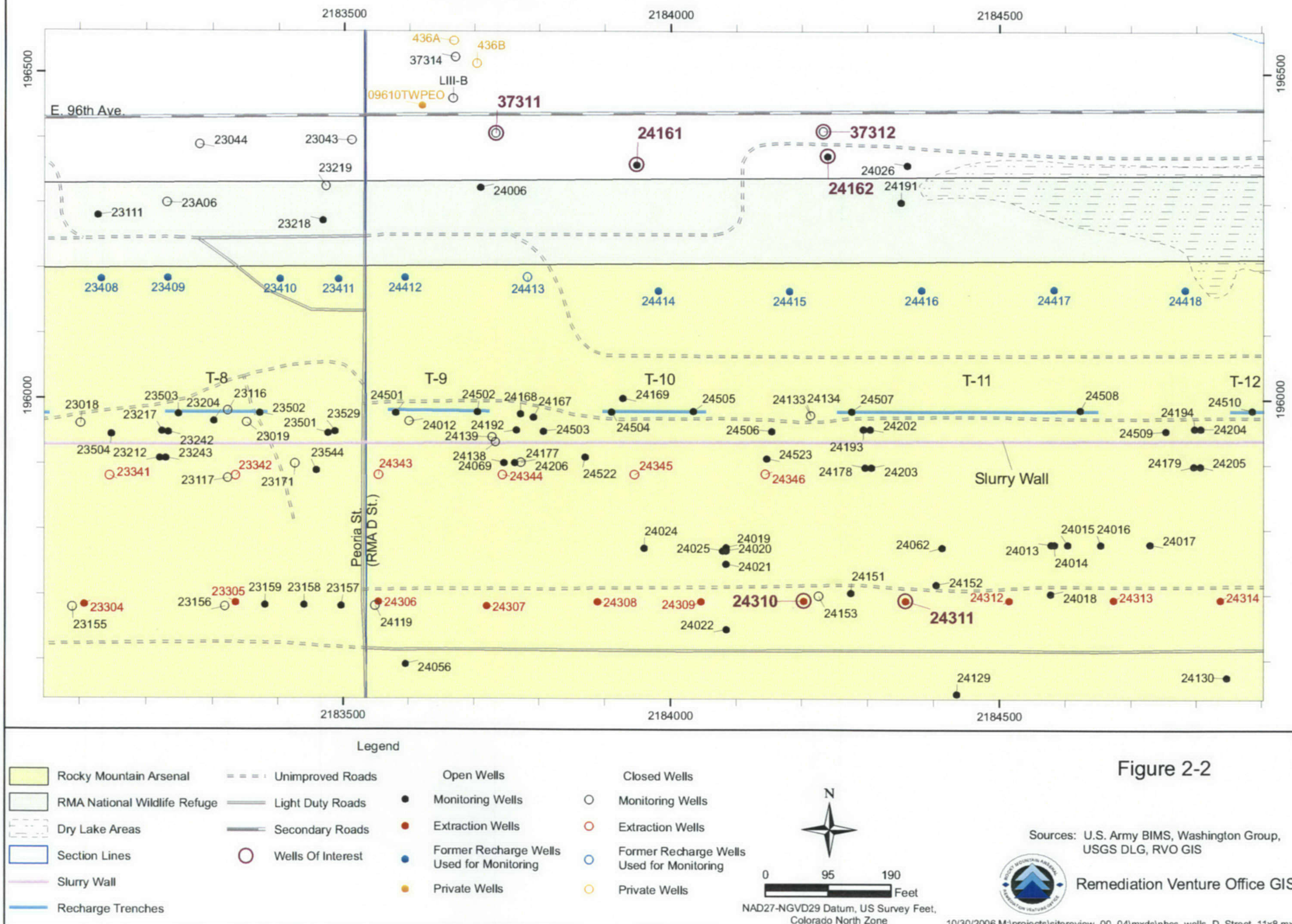

Figure 2-2

North Boundary Containment System Wells - East End

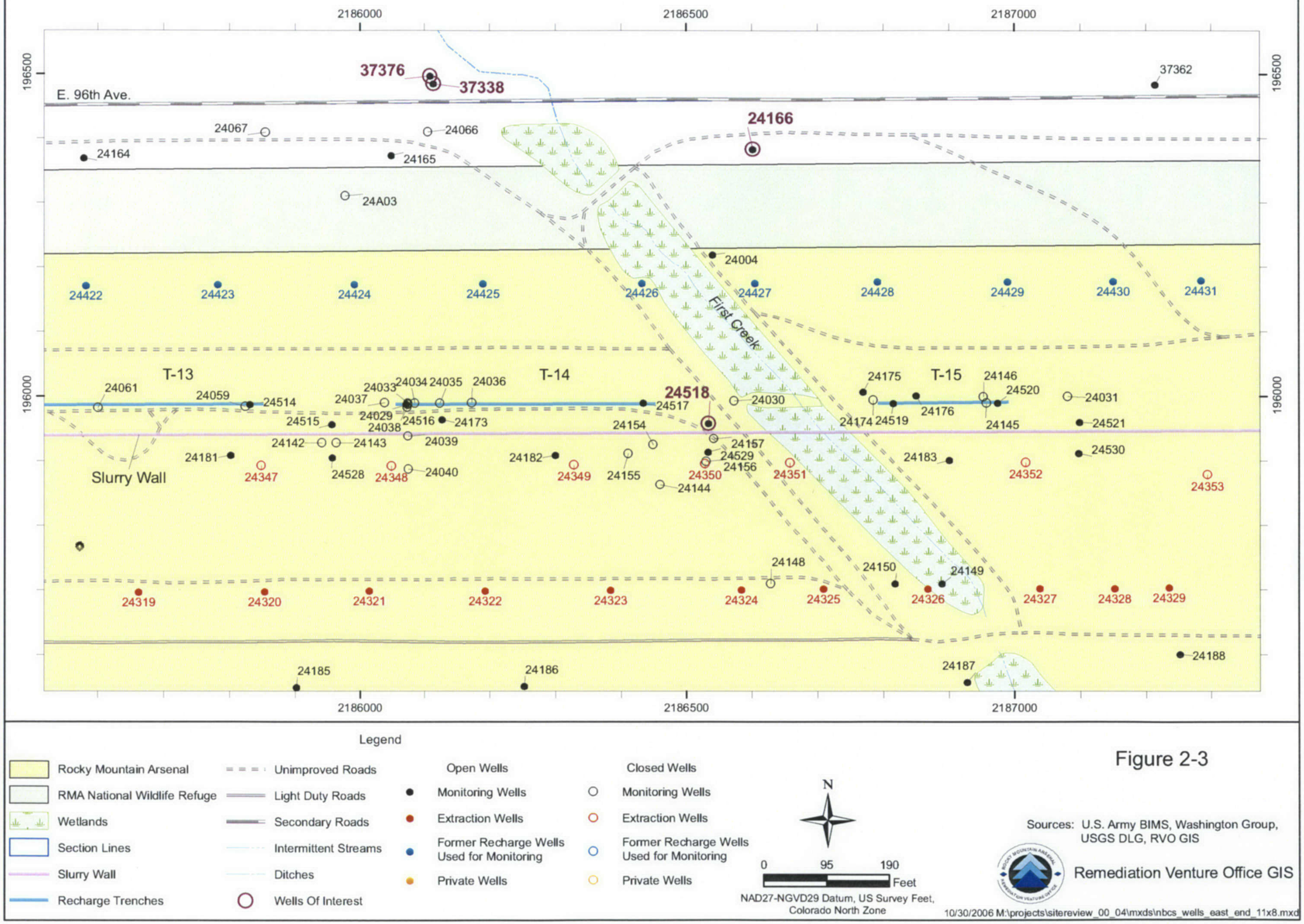

Figure 2-3

Sources: U.S. Army BIMS, Washington Group, USGS DLG, RVO GIS

Remediation Venture Office GIS

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Figure 2-4
North Boundary Containment System
Dieldrin Concentrations
in Well 37338

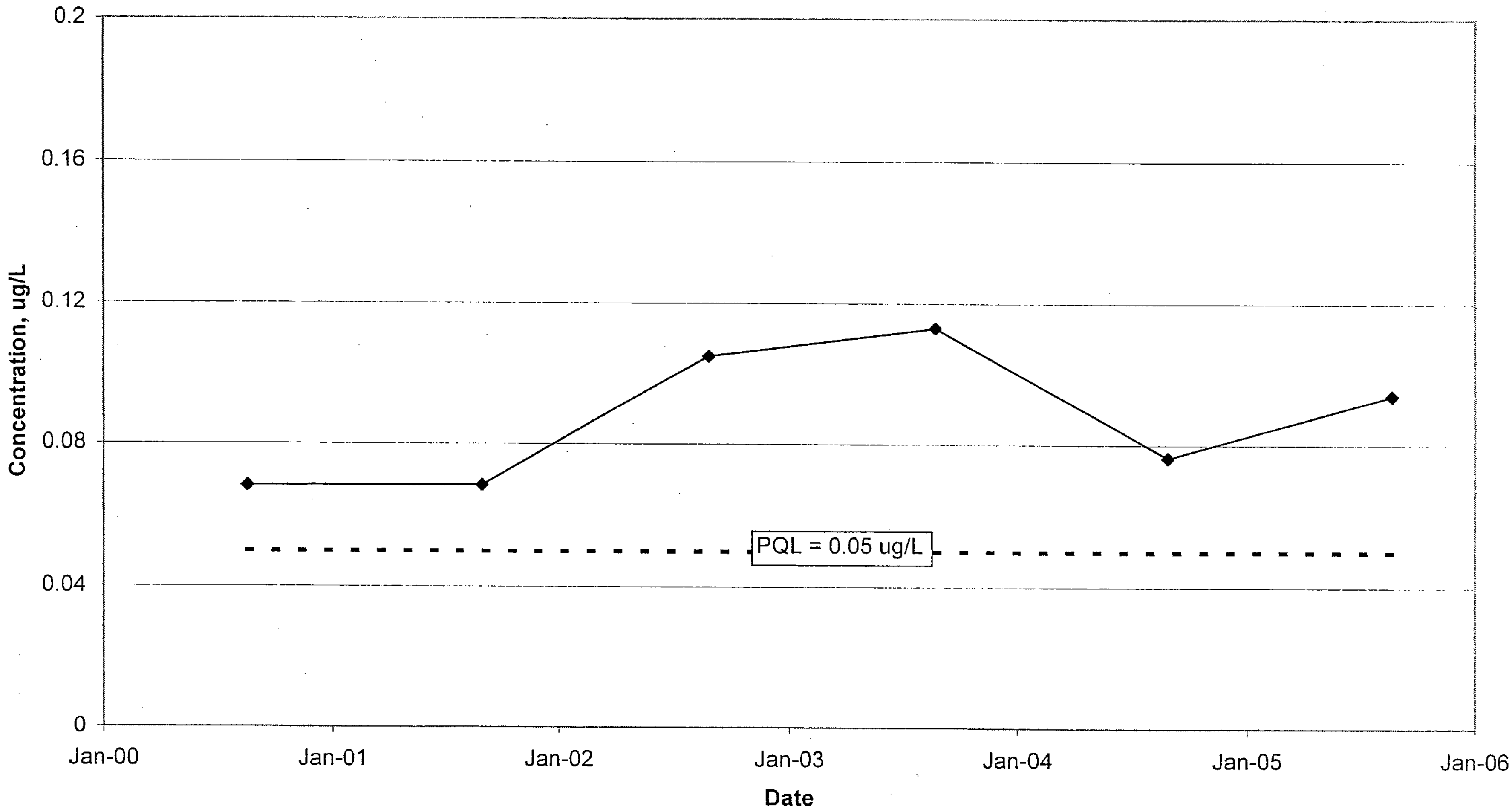


Figure 2-5
North Boundary Containment System
Dieldrin Concentrations
in Wells Near D Street

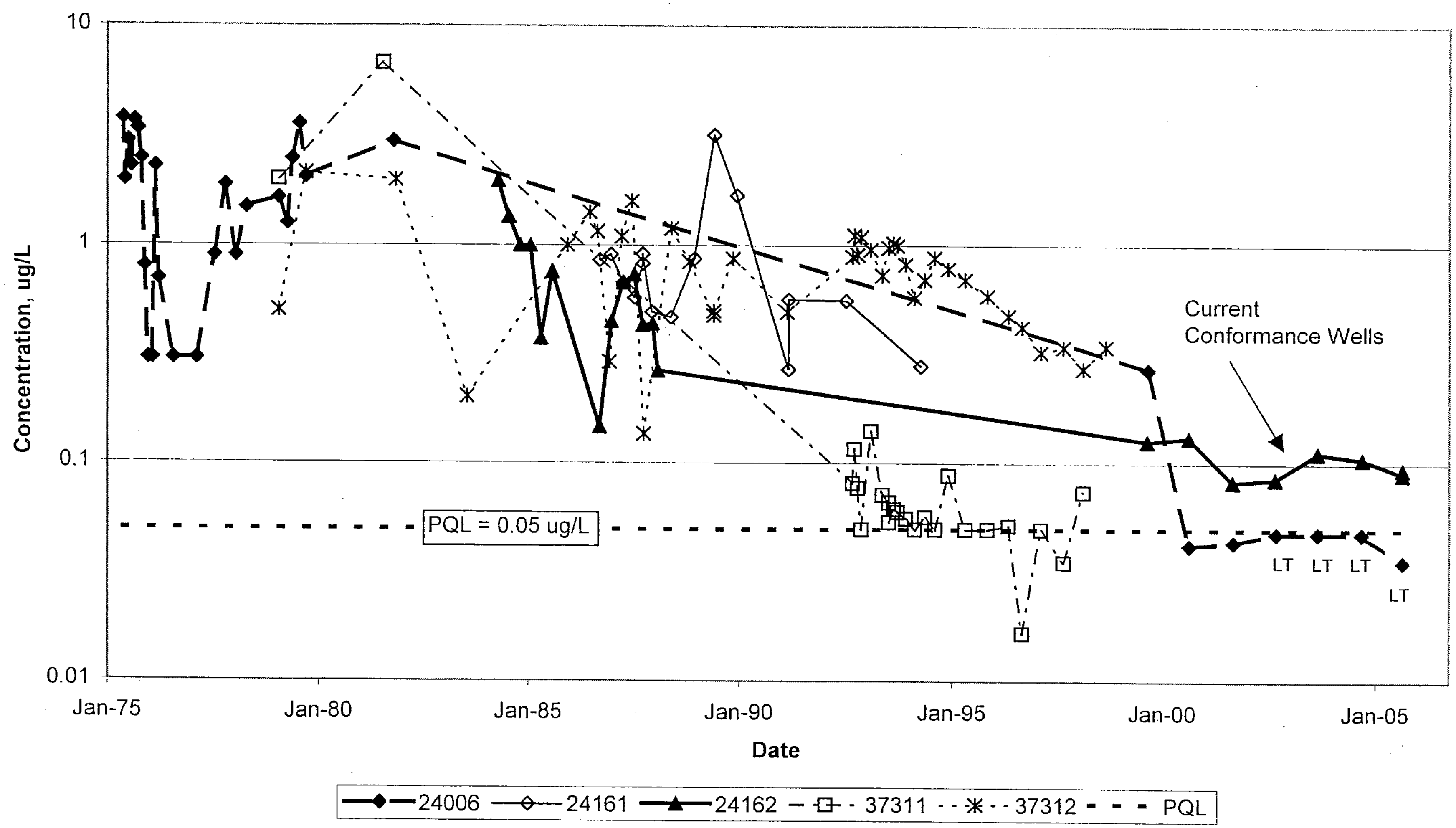
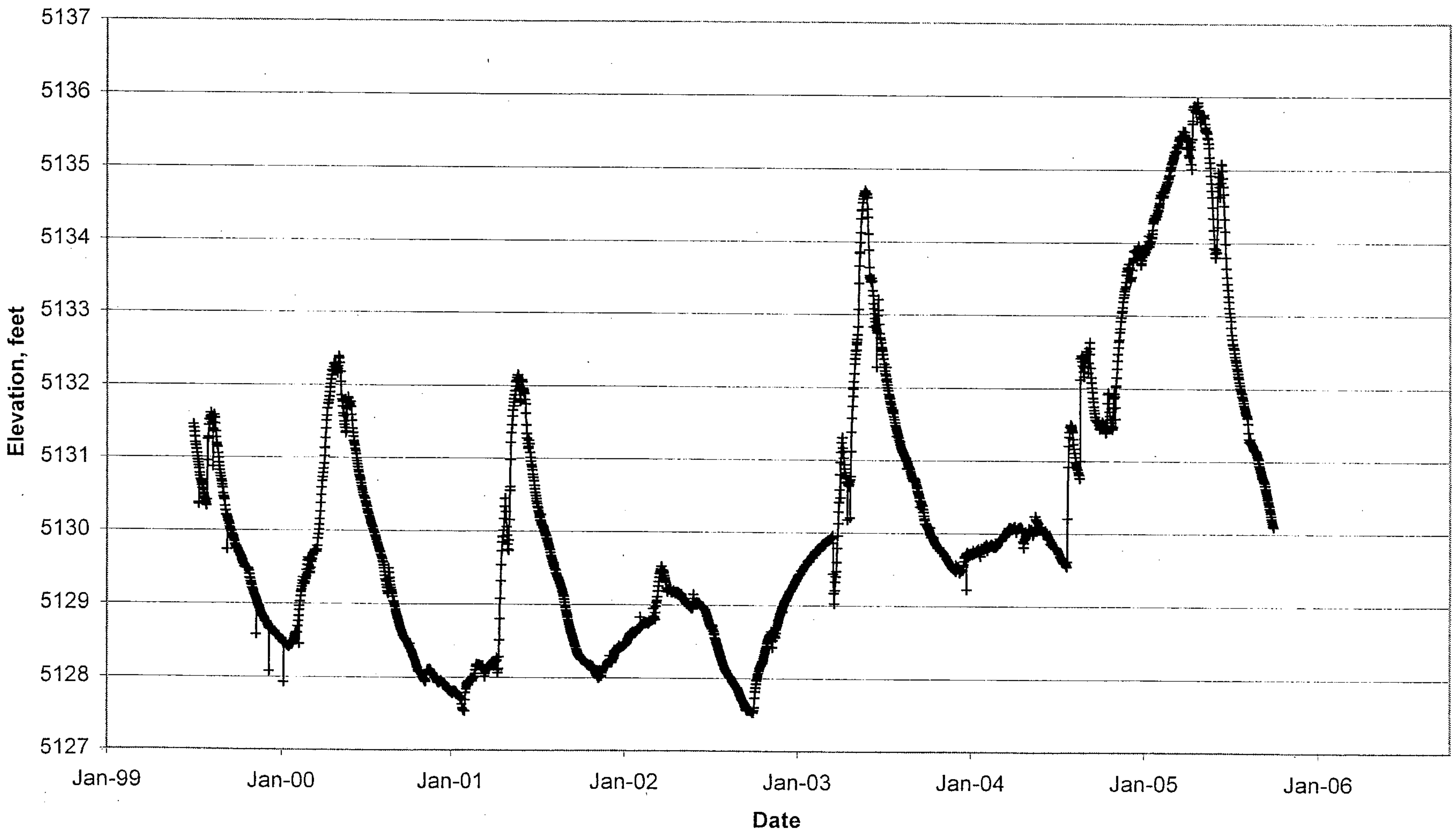


Figure 2-6
North Boundary Containment System
Water Levels in Well 24518



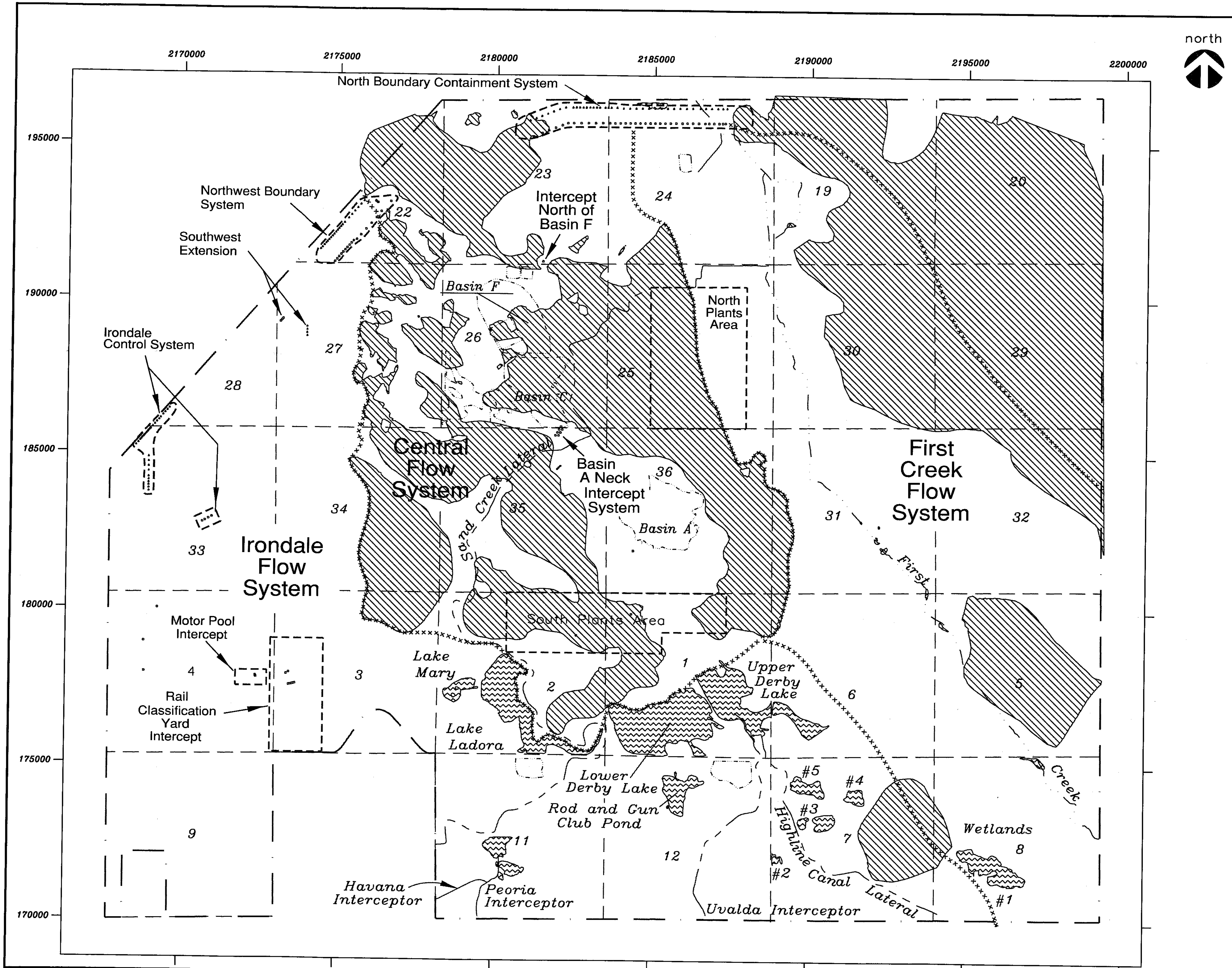


Figure 3-1

Rocky Mountain Arsenal

Groundwater Flow Systems

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION

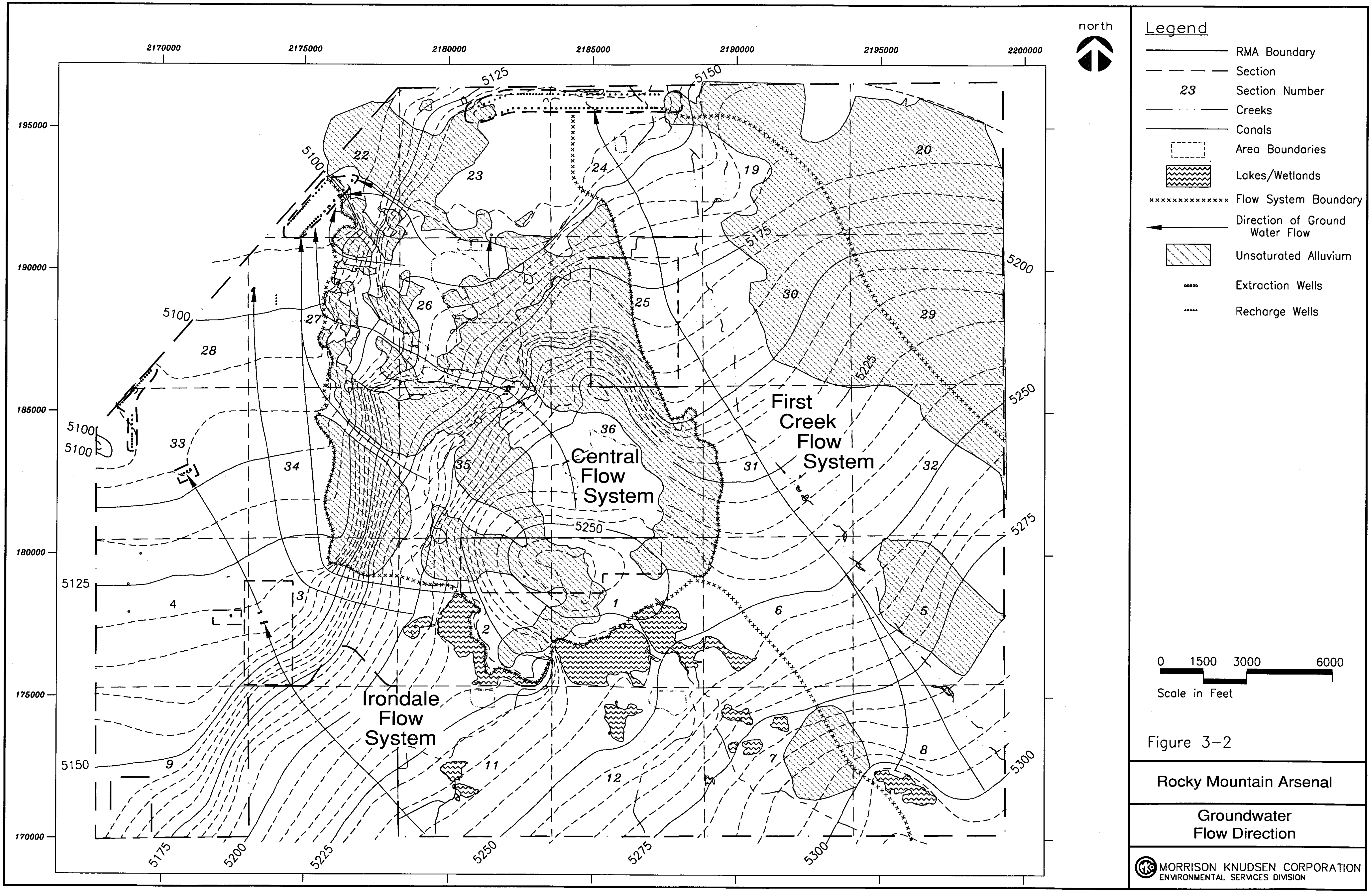


Figure 3-2

Rocky Mountain Arsenal

Groundwater Flow Direction

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION

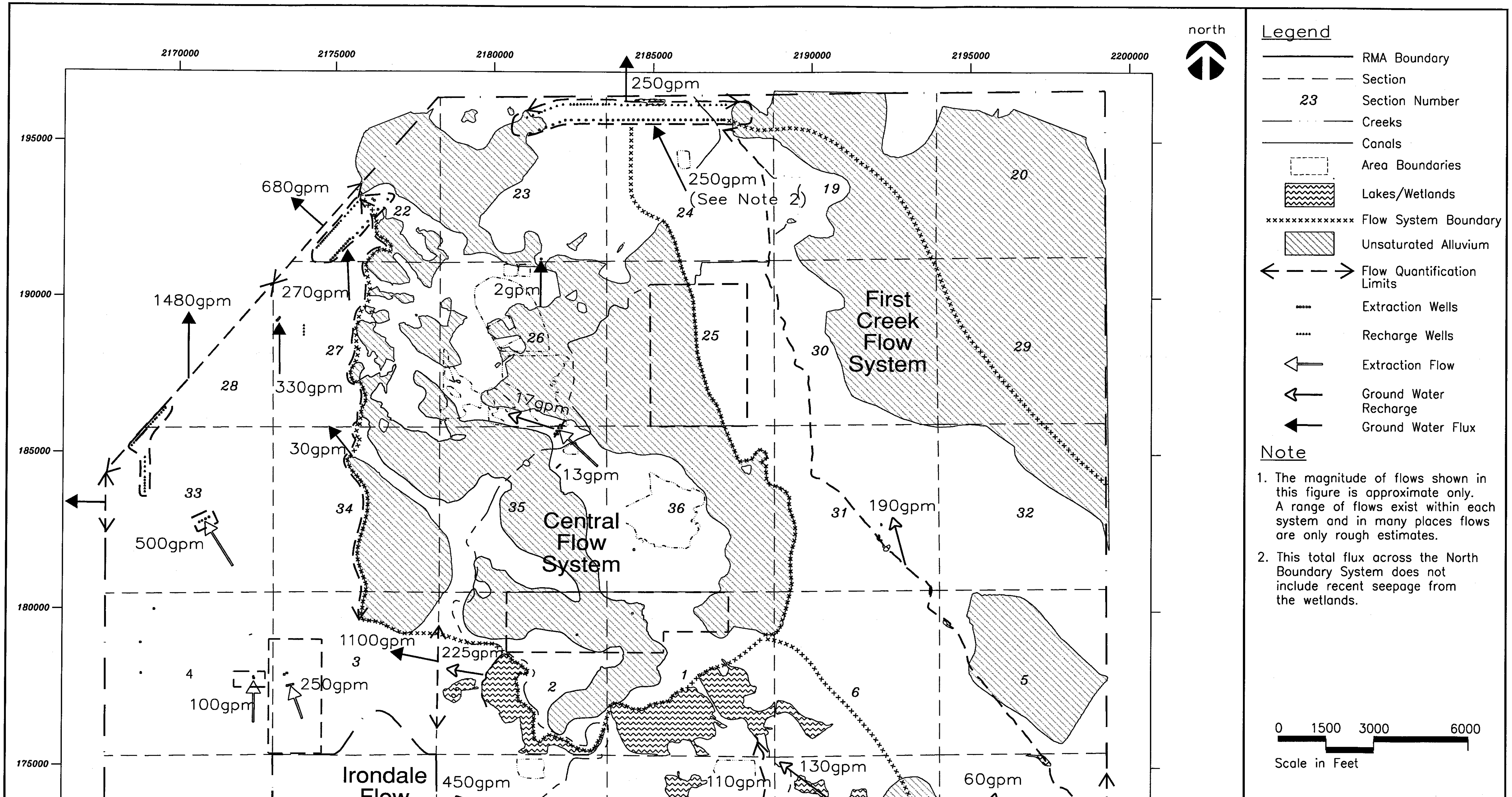
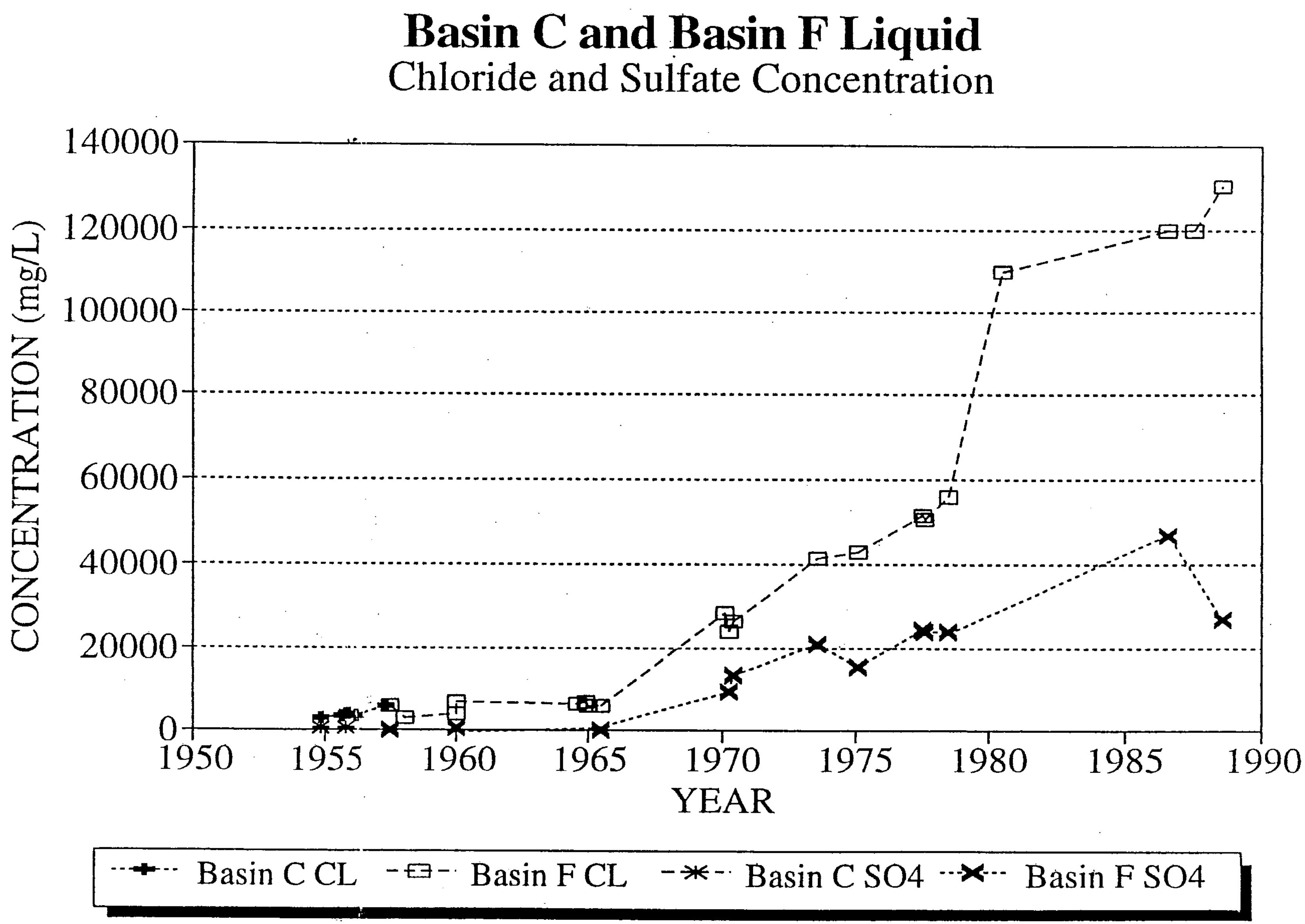


Figure 3-3

Rocky Mountain Arsenal

Approximate Quantities of Ground Water Flow



Basin C and Basin F Liquid
Chloride and Sulfate Concentration
CONCENTRATION (mg/L)
140000
120000
100000
80000
60000
40000
20000
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
YEAR
Basin C CL
Basin F CL
Basin C SO4
Basin F SO4

Figure 3-4

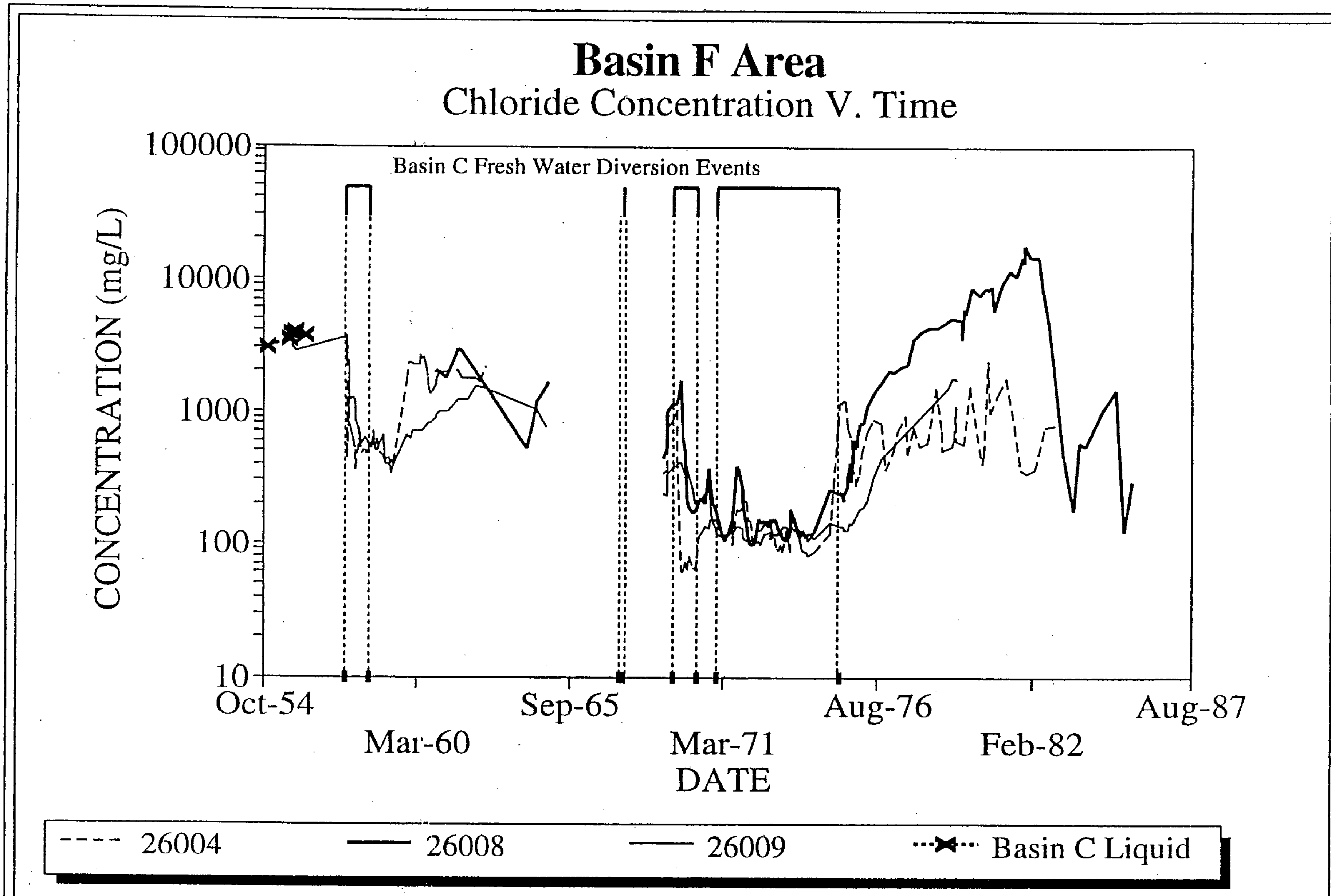
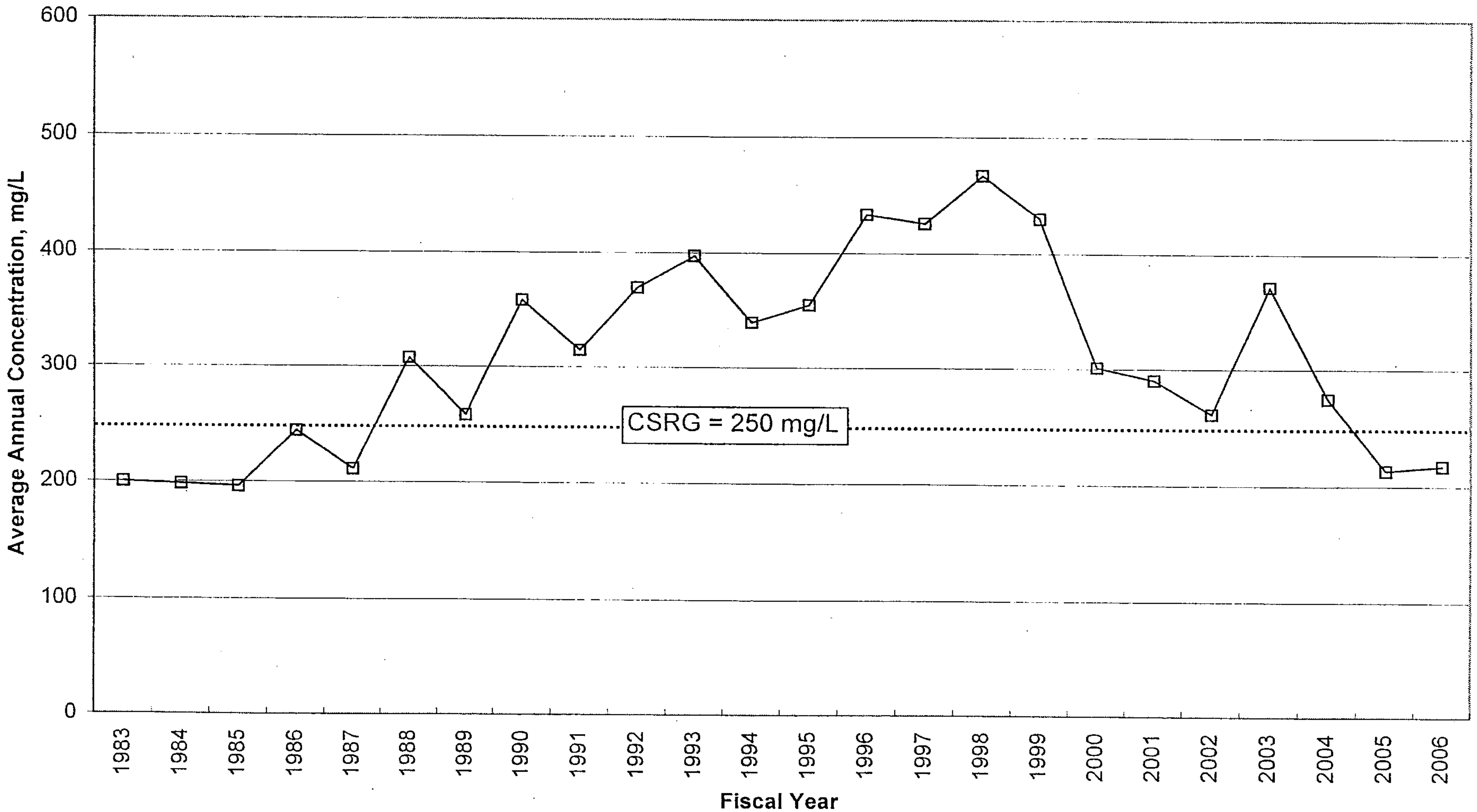
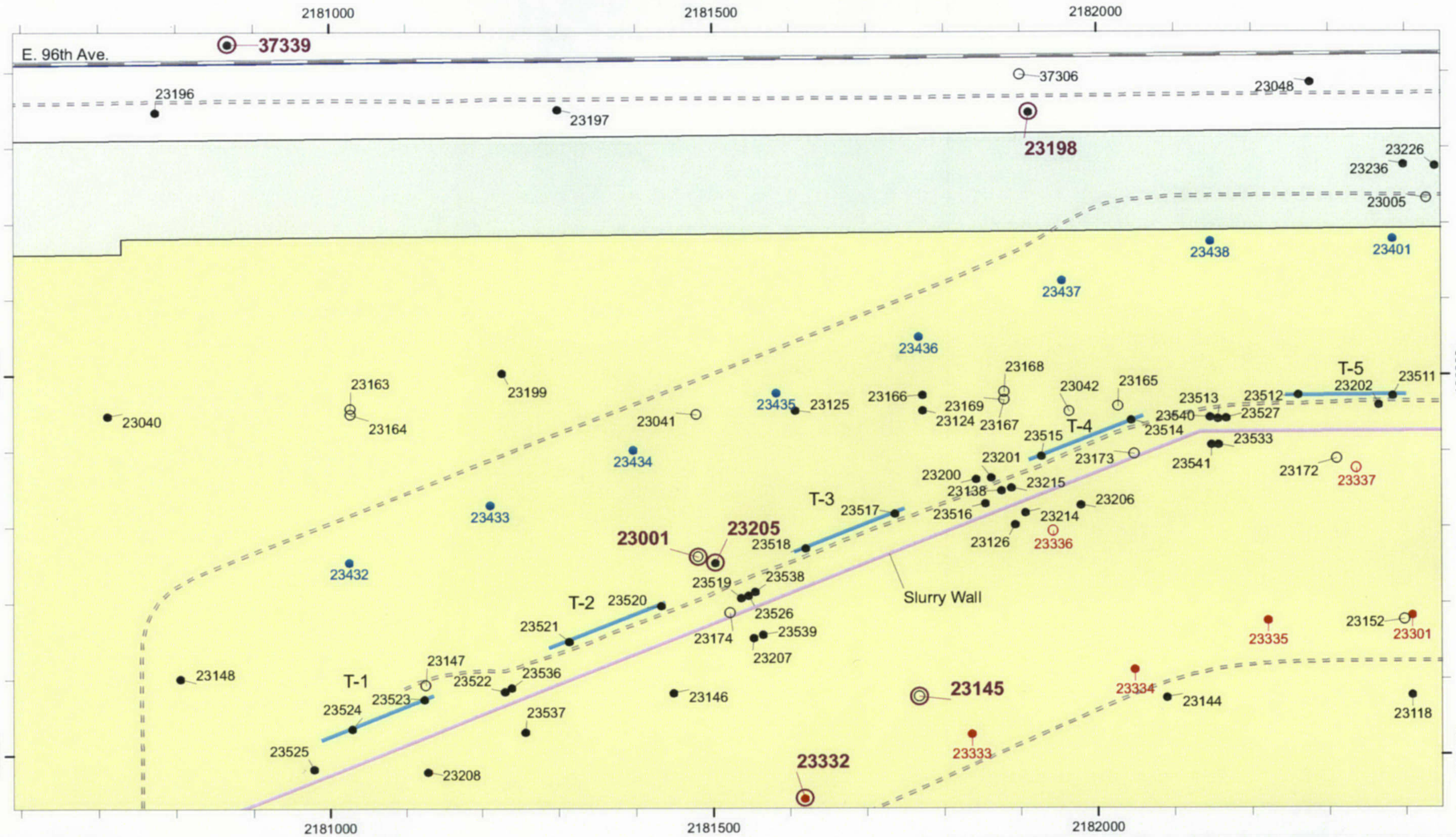

Basin F Area
Chloride Concentration V. Time
Basin C Fresh Water Diversion Events
CONCENTRATION (mg/L)
100000
10000
1000
100
10
Oct-54
Mar-60
Sep-65
Mar-71
Aug-76
Feb-82
Aug-87
DATE
26004
26008
26009
Basin C Liquid

Figure 3-5

Figure 3-6
North Boundary Containment System
Effluent Chloride Concentrations



North Boundary Containment System Wells - West End



Legend

- Rocky Mountain Arsenal
- RMA National Wildlife Refuge
- Section Lines
- Slurry Wall
- Recharge Trenches
- Unimproved Roads
- Light Duty Roads
- Secondary Roads
- Wells Of Interest

Open Wells	Closed Wells
Monitoring Wells	Monitoring Wells
Extraction Wells	Extraction Wells
Former Recharge Wells Used for Monitoring	Former Recharge Wells Used for Monitoring
Private Wells	Private Wells

N

0 95 190 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Figure 3-7

Sources: U.S. Army BIMS, Washington Group, USGS DLG, RVO GIS

Remediation Venture Office GIS

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Figure 3-8
North Boundary Containment System
Chloride Concentrations
(See Figure 3-7 for well locations)

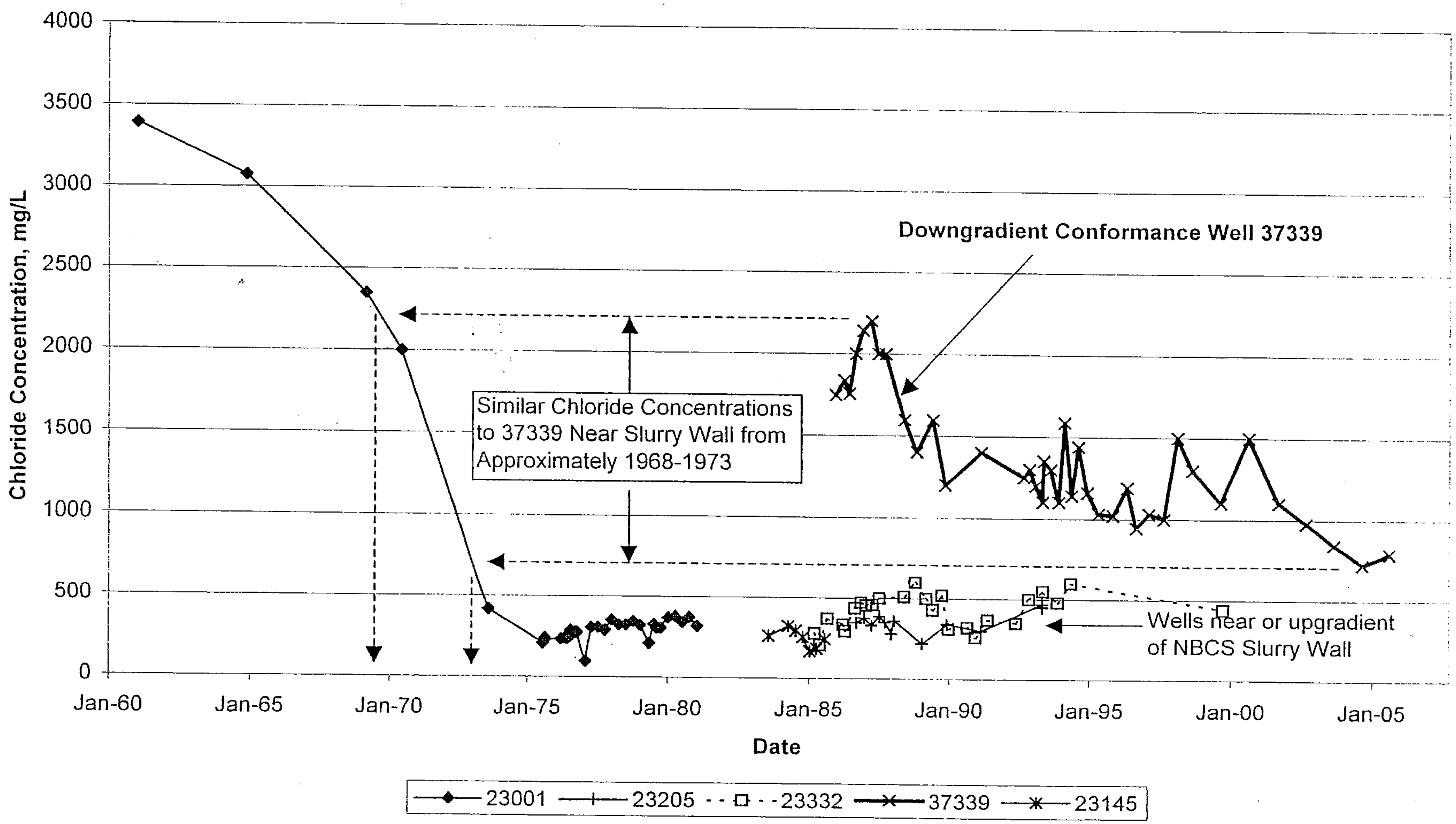
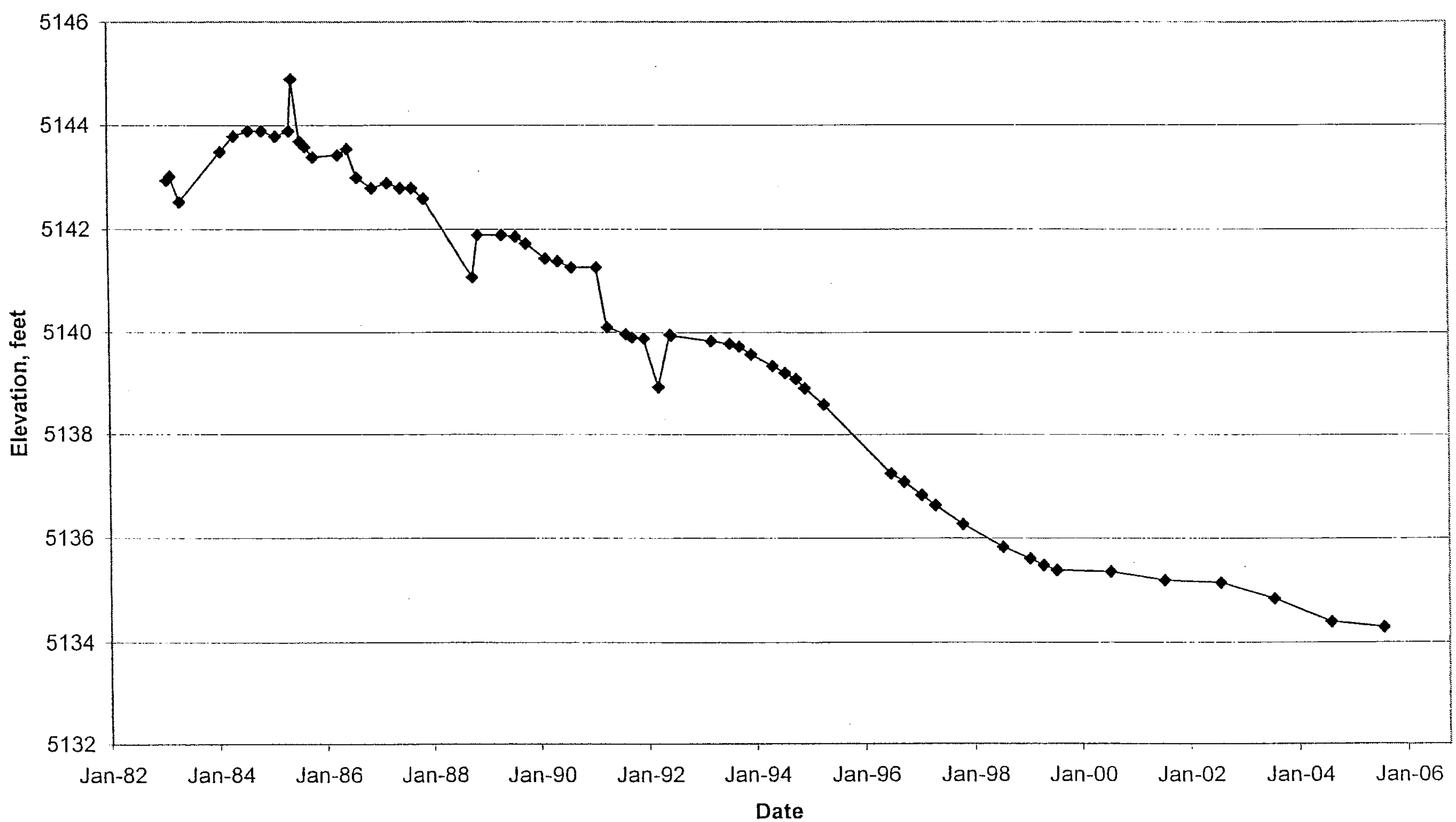
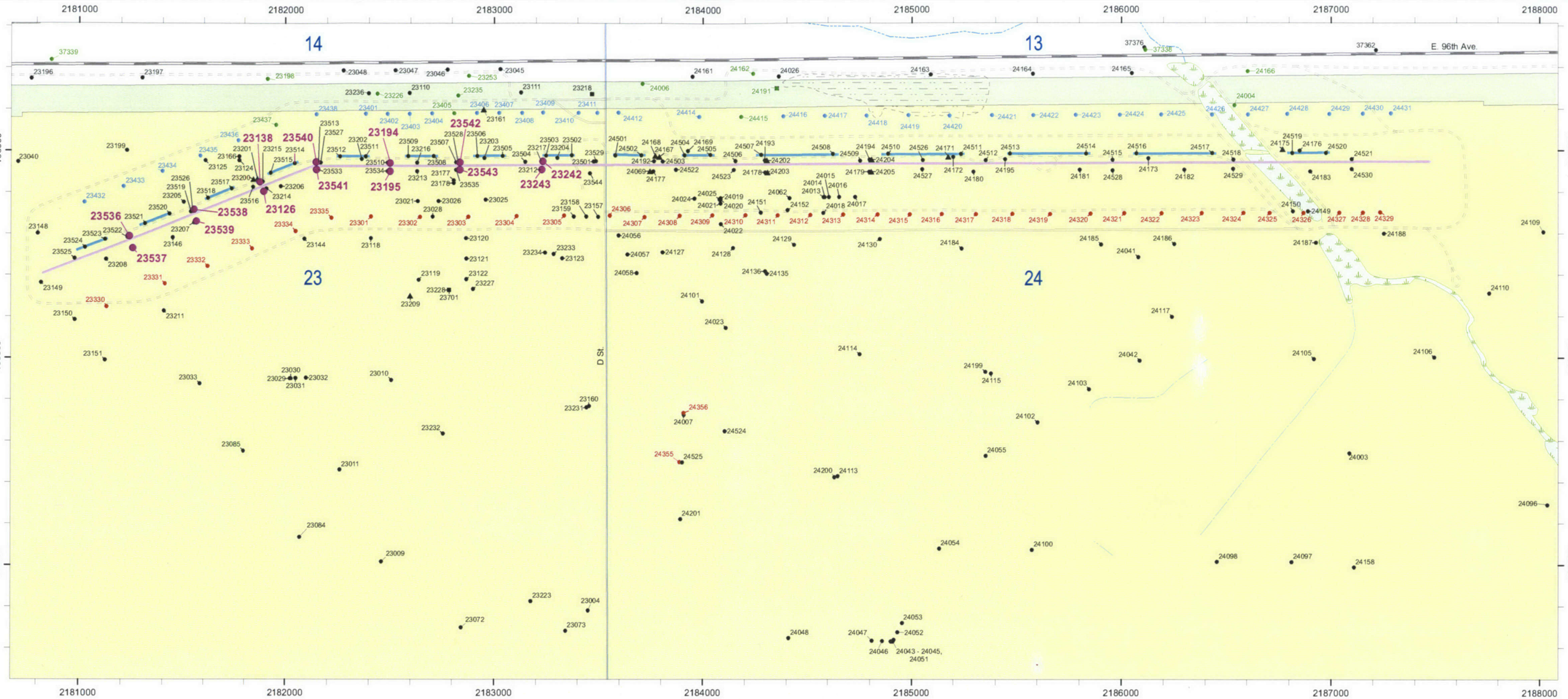


Figure 3-9
North of Basin F
Water Levels in Well 23095





FY04 North Boundary Monitoring Well Network of the Unconfined Aquifer Unconfined Denver Formation Well Pair Locations

Legend

- Rocky Mountain Arsenal
- RMA National Wildlife Refuge
- Dry Lake Areas
- Wetlands
- Lakes and Ponds
- Section Lines
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Unconfined Denver Wells
- Conformance Wells
- Extraction Wells
- Former Recharge Wells Used For Monitoring

Monitoring Wells

- Confined Flow System
- Unconfined Flow System
- Questionable Unconfined Flow System
- Questionable Flow System

N

0 250 500 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: USGS, DPRA, Inc., Washington Group, RMA Environmental Database, U.S. Army, Shell Chemical

Remediation Venture Office GIS

GIS Analyst: H. Kikel	Figure 4-1
Date: 10/30/2006	
Scale:	
Prepared For: E. Kaastrup	
Approved:	
DPRA	
File Location: M:\projects\sitereview_00_04\mxds\nbcs_uncon_den_wells_17x11.mxd	

ROCKY MOUNTAIN ARSENAL REMEDIATION VENTURE OFFICE

North Boundary Containment System Cross Section Locations

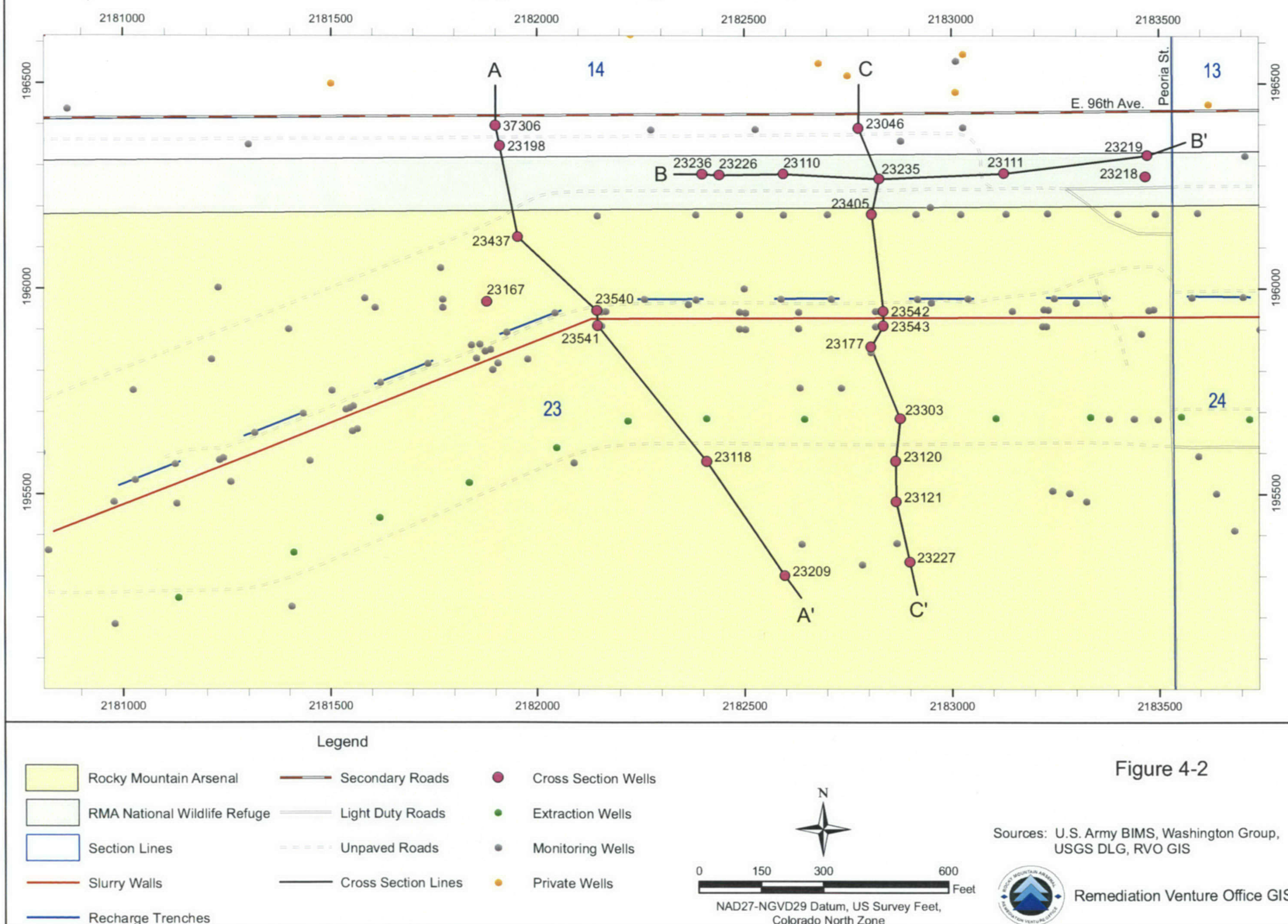
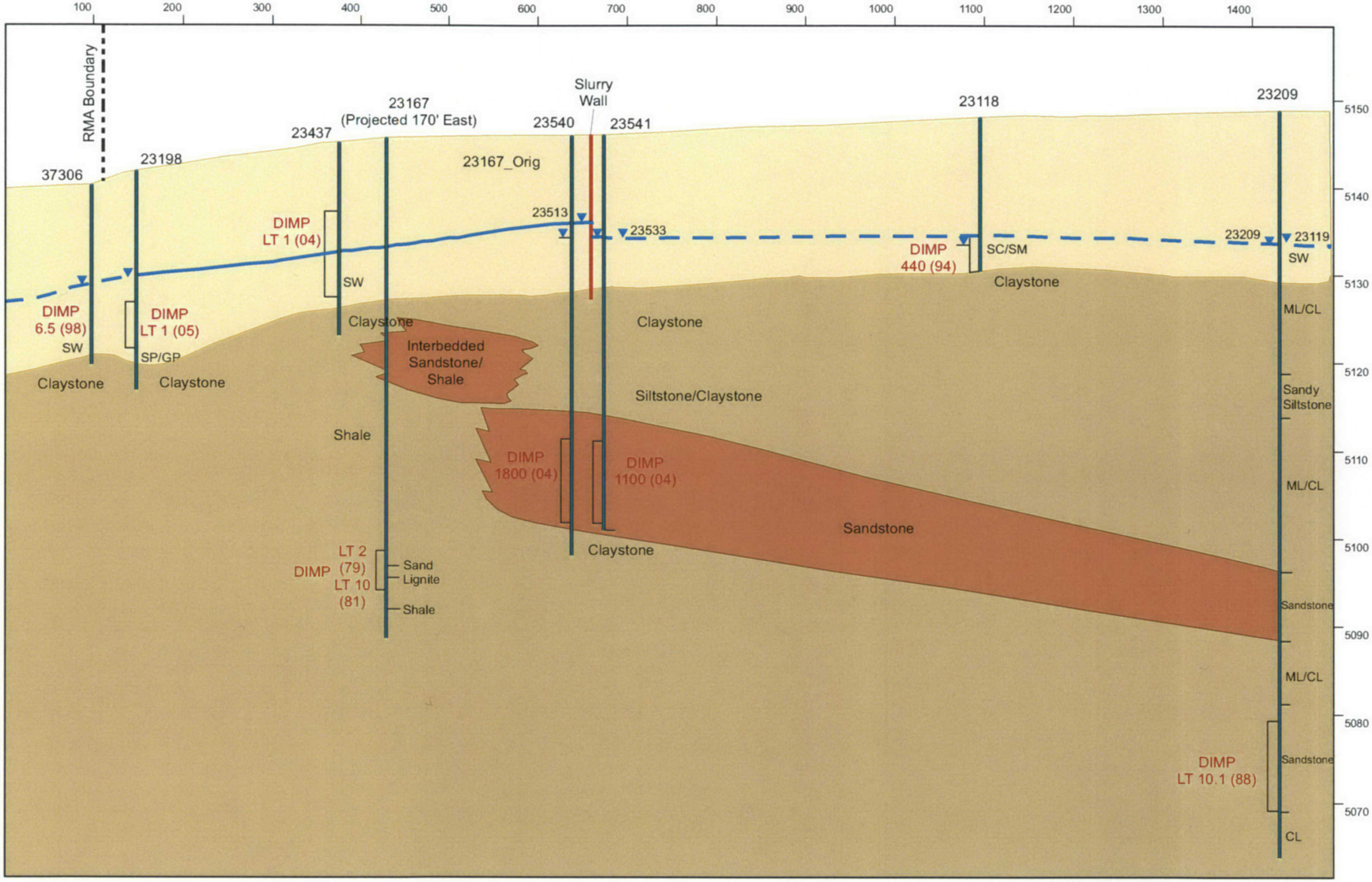


Figure 4-2

Geologic Cross Section A - A' - North Boundary Containment System



Legend

- April 2000 Water Level
- Approximate Water Level
- Alluvium
- Claystone
- Sandstone

0 75 150 300 Feet

Horizontal Scale: 1 inch equals 150 feet

Sources: Washington Group, RVO GIS

Remediation Venture Office GIS

Figure 4-3

Figure 4-4
North Boundary Containment System
DIMP Concentrations
in Well 23540

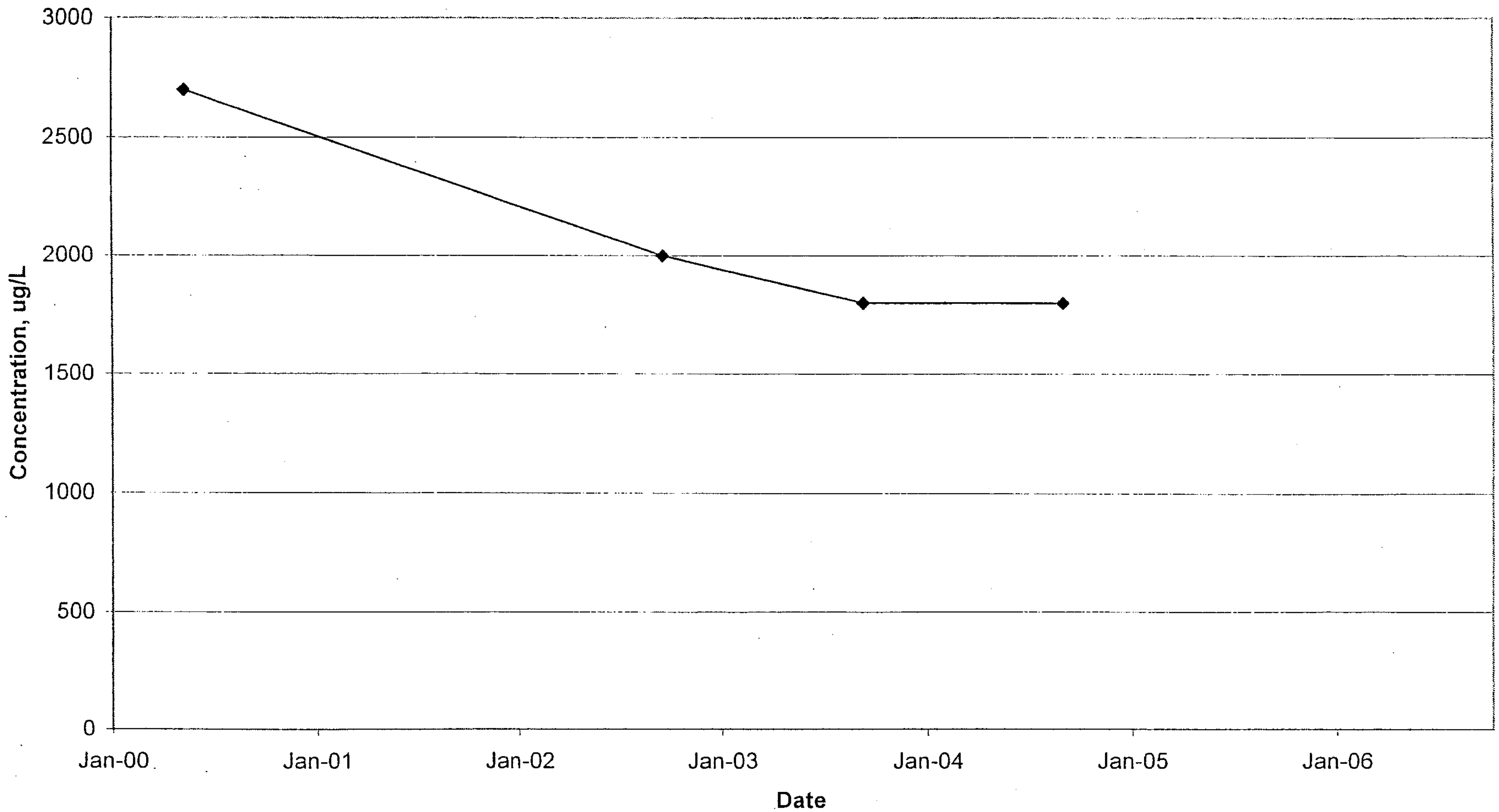
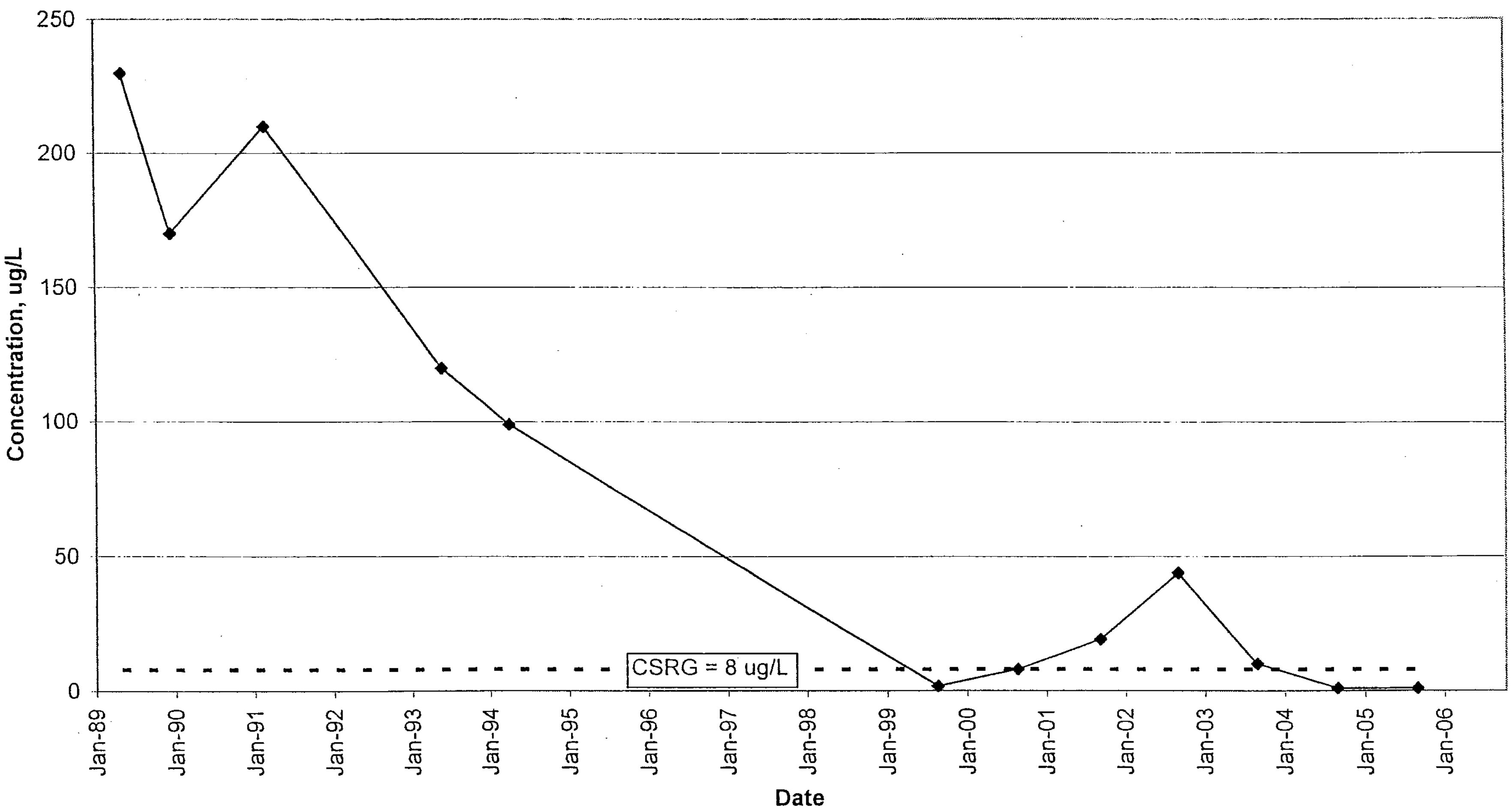
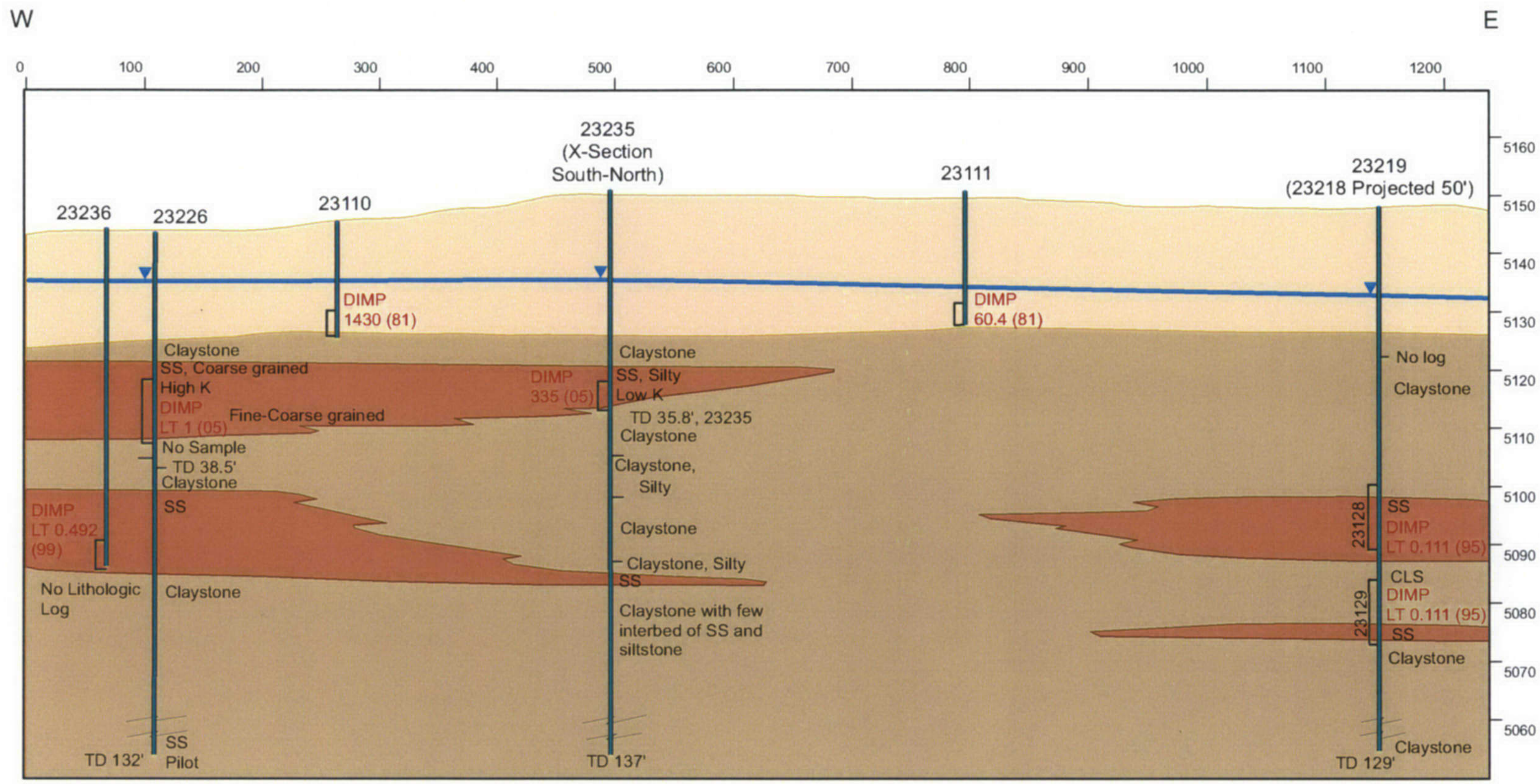


Figure 4-5
North Boundary Containement System
DIMP Concentrations
in Well 23198



Geologic Cross Section B - B' - North Boundary Containment System



Sources: Washington Group,
RVO GIS

Figure 4-6

Remediation Venture Office GIS

Figure 4-7
North Boundary Containment System
DIMP Concentrations
in Well 23235

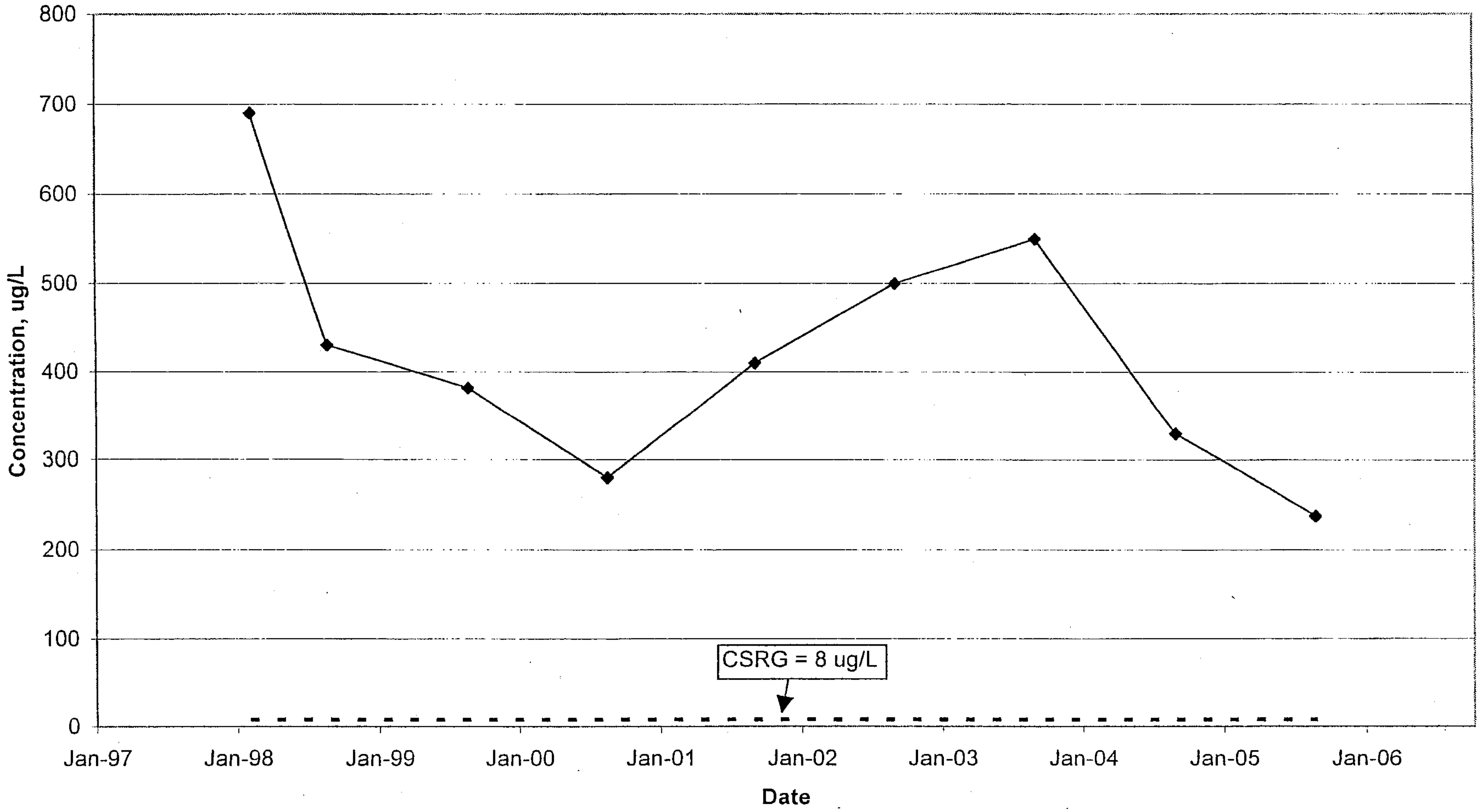
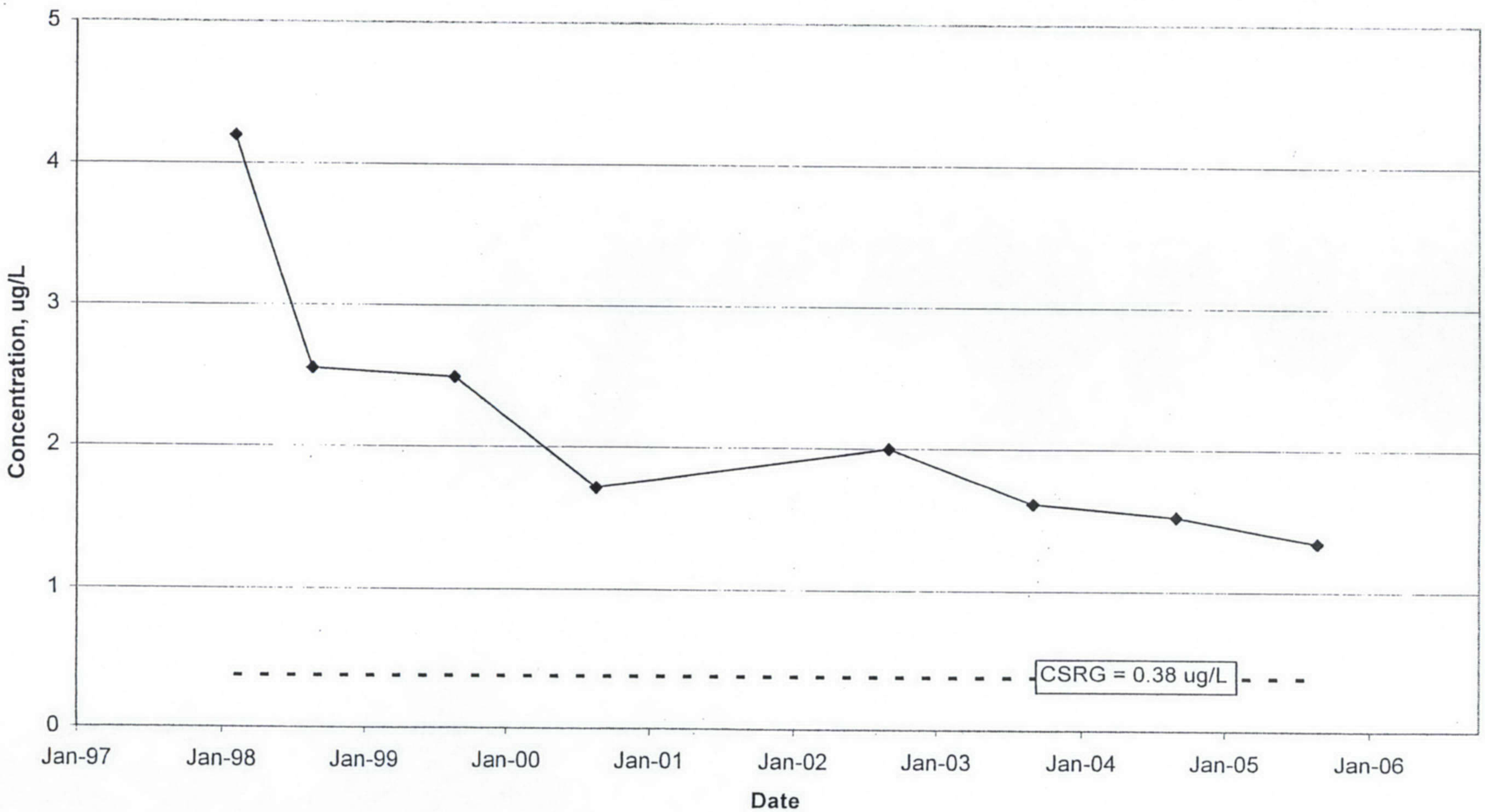


Figure 4-8
North Boundary Containment System
1,2-Dichloroethane (12DCLE) Concentrations
in Well 23235



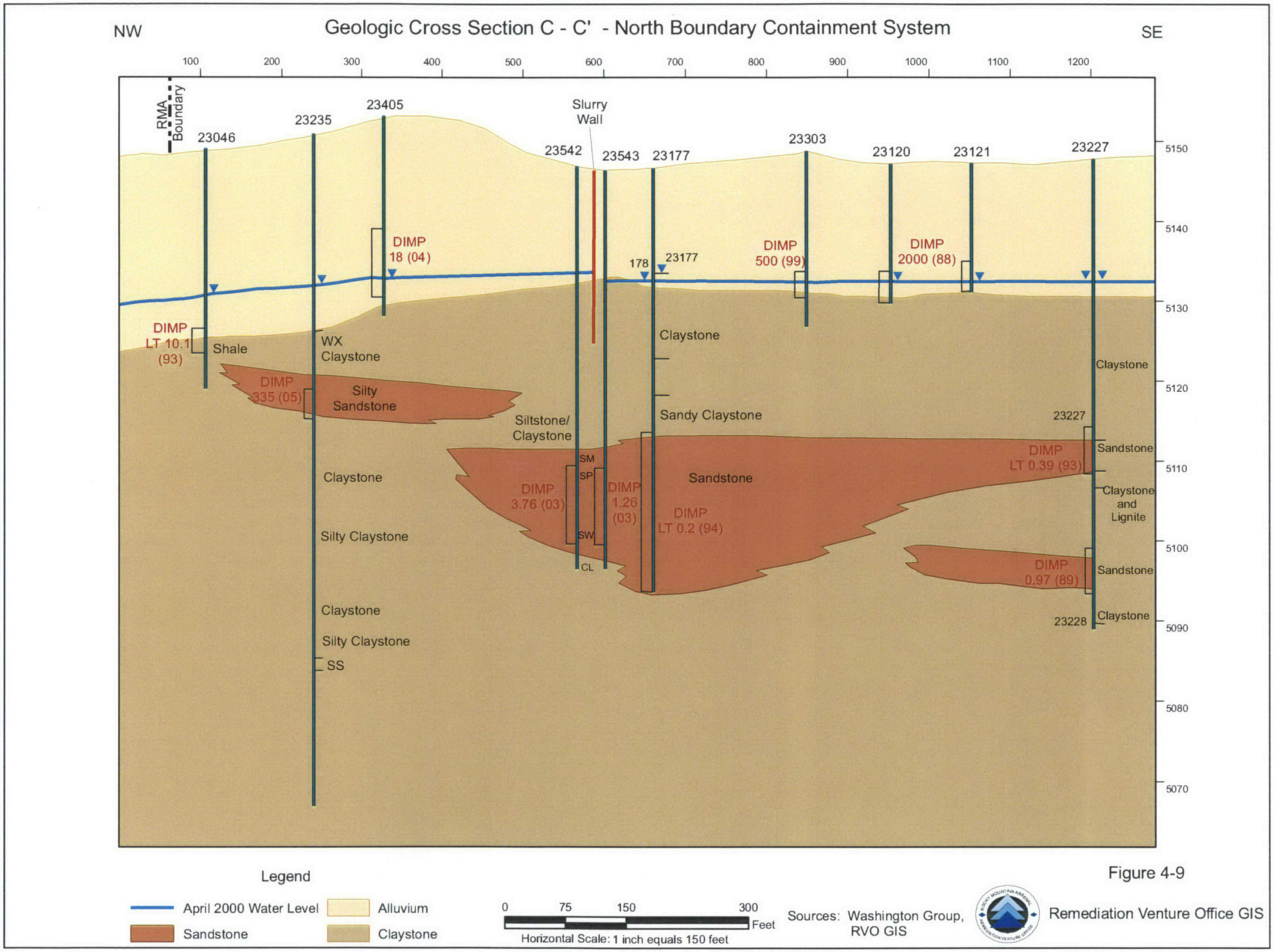

NW
Geologic Cross Section C - C' - North Boundary Containment System
SE
RMA Boundary
23046
23235
23405
Slurry Wall
23542
23543
23177
23303
23120
23121
23227
DIMP 18 (04)
DIMP 500 (99)
DIMP 2000 (88)
DIMP LT 10.1 (93)
Shale
WX Claystone
DIMP 335 (05)
Silty Sandstone
Claystone
Sandy Claystone
Siltstone/ Claystone
Sandstone
DIMP 3.76 (03)
DIMP 1.26 (03)
DIMP LT 0.2 (94)
DIMP LT 0.39 (93)
Claystone and Lignite
DIMP 0.97 (89)
Silty Claystone
SS
23228
Legend
April 2000 Water Level
Sandstone
Alluvium
Claystone
Horizontal Scale: 1 inch equals 150 feet
Sources: Washington Group, RVO GIS
Remediation Venture Office GIS

Figure 4-9

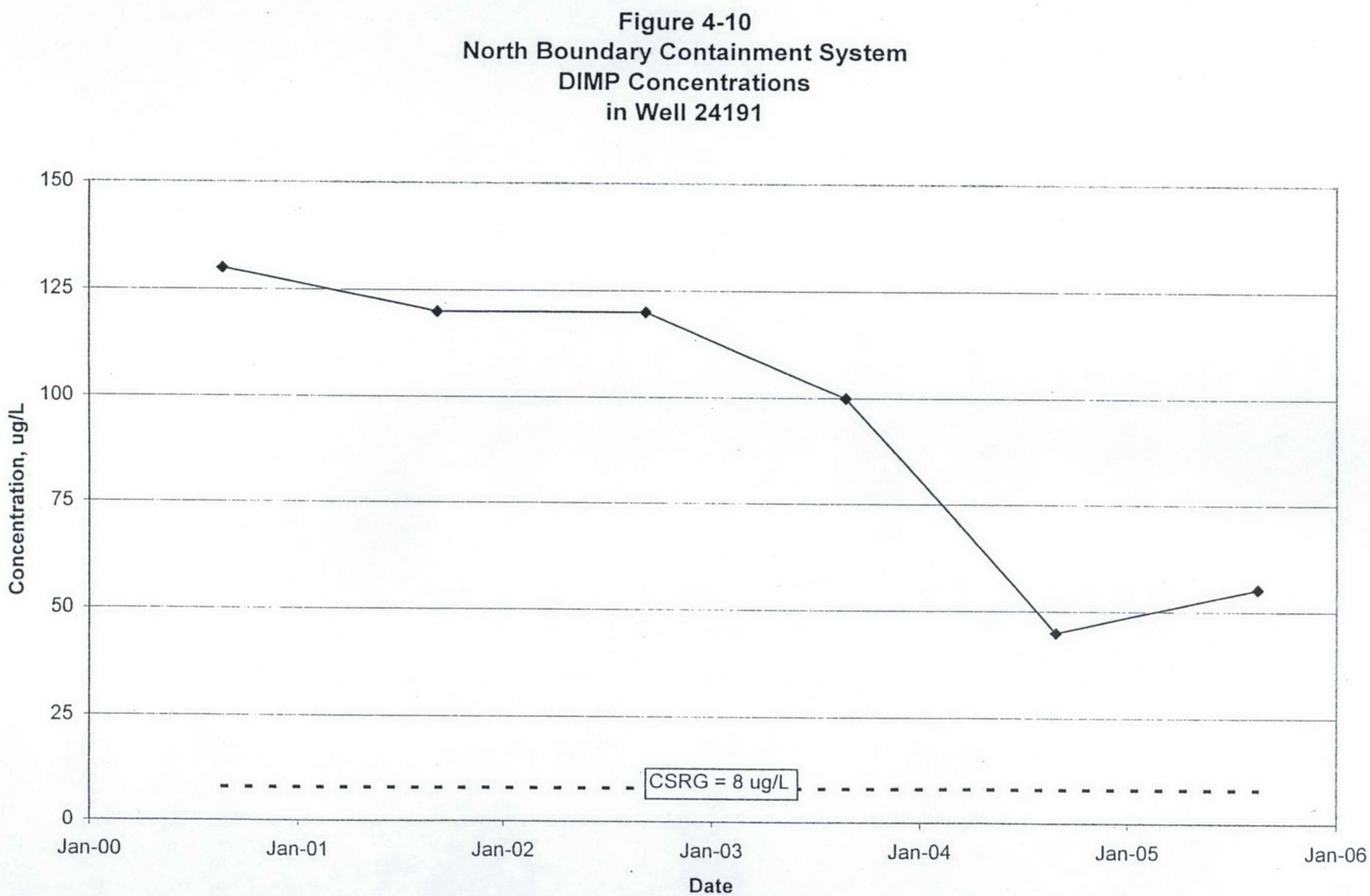
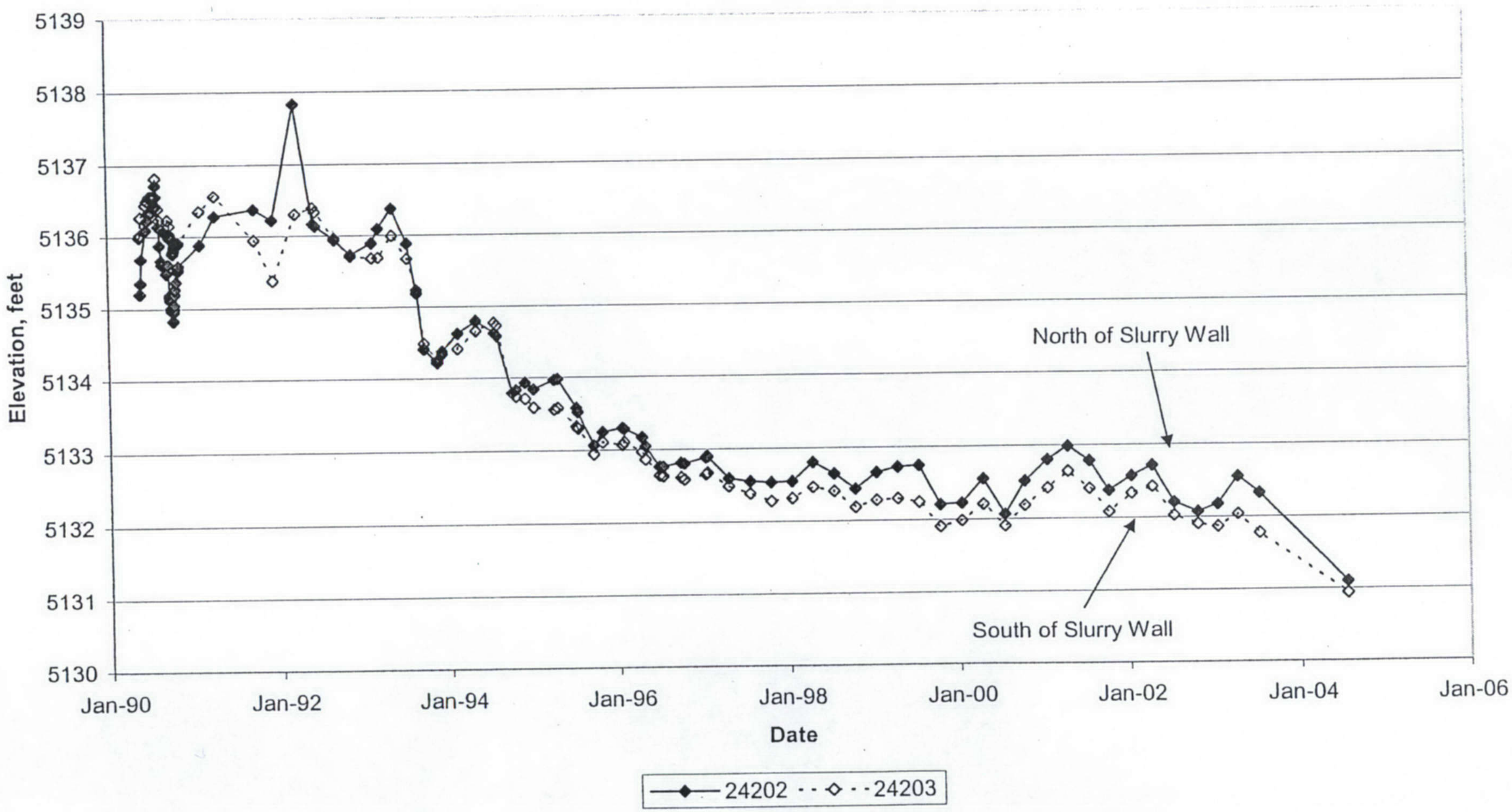


Figure 4-10
North Boundary Containment System
DIMP Concentrations
in Well 24191
150
125
100
75
50
25
0
Concentration, ug/L
CSRG = 8 ug/L
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Date

Figure 4-11
North Boundary Containment System
Denver Well Hydrographs



ATTACHMENT A

TABLE 1
FY2000 NBCS DENVER WELL RESULTS -- CSRG EXCEEDANCES

Wells are listed by pairs from west to east. Wells with CSRG exceedances of organic analytes on the north side of the slurry wall are shown in **bold**.

Well[1]	**Gradient**	**Analytes exceeding CSRGs**
West End		
23536 (N)	Reverse	chloroform[2], sulfate
23537 (S)		chloride, sulfate
23538 (N)	Reverse	sulfate
23539 (S)		-
23138 (N)	Reverse	chloride
23126 (S)		chloride, sulfate
Bend in Slurry Wall		
23540 (N)	Flat	chloride, DIMP, fluoride
23541 (S)		chloride, DIMP
23194 (N)	Flat	chloride, sulfate
23195 (S)		chloride, DIMP, sulfate
23542 (N)	Forward	sulfate
23543 (S)		chloride, sulfate
23242 (N)	Reverse	1,2-dichloroethane, chloride, DIMP, NDMA, tetrachloroethylene
23243 (S)		1,2-dichloroethane, chloride, DIMP, dieldrin[2], NDMA, sulfate, tetrachloroethylene
D Street		

Notes:
1. The position of the well in each pair relative to the slurry wall is indicated (N = North, S = South).
2. Questionable data.

TABLE 2
FY2000 NBCS DENVER WELL RESULTS -- DETECTIONS

Wells are listed by pairs from west to east.

Well[1]	**Gradient**	**Analytes Detected[2, 3] (CSRG Exceedances in** Bold **& with an** *)
West End		
23536 (N)	Reverse	**CHCL3***, DBRCLM, **SO4***
23537 (S)		CHCL3, **CL***, **SO4***
23538 (N)	Reverse	12DCLE, BRDCLM, CHCL3, DBRCLM, **SO4***
23539 (S)		BRDCLM, CHCL3, DBRCLM
23138 (N)	Reverse	12DCLE, CHCL3, DIMP, **CL***
23126 (S)		12DCLE, CHCL3, **CL***, DIMP, **SO4***
Bend in Slurry Wall		
23540 (N)	Flat	12DCLE, CHCL3, **CL***, CPMSO2, **DIMP***, **F***, TCLEE, TRCLE
23541 (S)		CHCL3, **CL***, CPMSO, **DIMP***, TCLEE
23194 (N)	Flat	12DCLE, CHCL3, **CL***, DIMP, TCLEE, **SO4***
23195 (S)		CHCL3, **CL***, **DIMP***, **SO4***, TCLEE
23542 (N)	Forward	CHCL3, DIMP, **SO4***
23543 (S)		CHCL3, **CL***, DIMP, **SO4***
23242 (N)	Reverse	**12DCLE***, CHCL3, **CL***, CPMSO, CPMSO2, DBCP, DCPD, **DIMP***, ENDRNK, ESFSO4, LIN, **NNDMEA***, **TCLEE***, TRCLE
23243 (S)		**12DCLE***, AENSLF, CHCL3, **CL***, CPMSO, CPMSO2, DBCP, DCPD, **DIMP***, **DLDRN***, ENDRNK, ESFSO4, LIN, **NNDMEA***, **SO4***, **TCLEE***, TRCLE
D Street		

Notes:
1. The position of the well in each pair relative to the slurry wall is indicated (N = North, S = South).
2. Chloride, fluoride, and sulfate were detected in all wells but are only shown where they exceeded the CSRG.
3. Detections of 12DMB, C6H6, CH2CL2, and MEC6H5 occurred but were not listed because the investigative samples had similar concentrations as the QC blanks and are questionable.

ATTACHMENT B

NBCS DENVER WELL FLOW AND MASS BALANCE CALCULATIONS

Wells 23540/23541

Flow

K = 0.63 ft/day
i = 0.001 ft/ft
a = 200 ft x 15 ft = 3000 ft2

Q = Kia = 0.01 gpm

DIMP Mass Balance

¼ T4/5 Flow = 4.5 gpm
(4.5 gpm 1 ppb DIMP + 0.01 gpm x 2700 ppb DIMP)/4.51 gpm = 7 ppb

Wells 23242/23243

Flow

K = 0.63 ft/day
i = 0.007
a = 400 ft x 5 ft = 2000 ft2

Q = Kia = 0.05 gpm

Mass Balance

T8 flow = 14.6 gpm
(14.6 gpm x 1 ppb DIMP + 0.05 gpm x 1400 ppb DIMP)/14.65 gpm = 5.8 ppb

Well 23235

Flow

K = 0.63 ft/day
i = 0.008 ft/ft
a = 400 x 10 ft = 4000 ft2

Q = Kia = 0.1 gpm

Mass Balance

½ T6/7 flow = 20.3 gpm
(20.3 gpm x 1 ppb DIMP + 0.1 gpm x 400 ppb DIMP)/20.4 gpm = 3 ppb